AN ANALYSIS OF AIR FORCE ACQUISITION ENGINEERING OFFICER'S PERCEPTIONS OF THE ADEQUACY OF THEIR PREPARATION FOR MANAGEMENT

THESIS

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AFIT/GSM/LAS/94M-1

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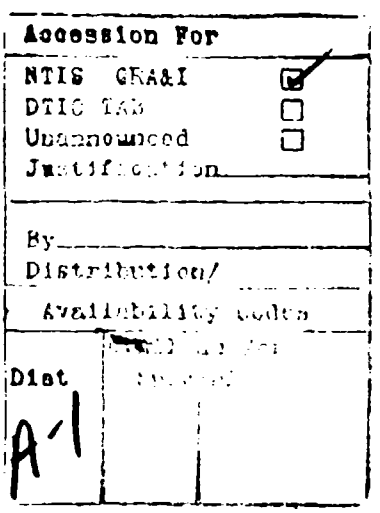

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THESIS

Presented to the Faculty of the Graduate School of Logistics and Acquisition Management of the Air Force Institute of Technology Air University In Partial Fulfillment of the Requirement for the Degree of Master of Science in Systems Management

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Preface

The purpose of this study was to determine how much time Air Force acquisition engineers spend in performing management functions, how engineers perceive their management training, and which types of training contribute most to managerial competency.

The results from surveys of acquisition engineers assigned to ASC/EN, Wright-Patterson AFB, OH and their supervisors revealed that engineers do indeed spend substantial amounts of time performing management functions. Engineers did not indicate their management training had been inadequate, but did indicate some additional training would be beneficial. The most effective contributors to managerial competency were experience, an aptitude for management, and having a mentor.

I had a great deal of help from others in performing the research and writing this thesis for which I would like to express my gratitude. I am indebted to Major K. Grant, my faculty advisor, for his patience and assistance over a considerable period of time. I would also like to thank Lt Col G. Carpenter of ASC/ENO for sponsoring the research. Finally, I wish to thank my family for their patience and understanding while I neglected them to complete this work.

Steven E. Woodruff

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Abstract

The purpose of this study was to determine how much time Air Force acquisition engineers spend in performing management functions, how those engineers perceive their management training, and which types of training contribute the most to managerial competency.

The results from surveys of 215 acquisition engineers assigned to ASC/EN, Wright-Patterson AFB, OH and their supervisors revealed that engineers do indeed spend substantial amounts of time performing management functions. Slightly more than half the engineers reported spending at least 50% of an average workday performing management functions.

Over 53% of engineers responding to the survey felt their management training had been either "excellent" or "good." Management skills were rated either "excellent" or "good" by 72% of the respondents. In the key area of communication skills, 87% agreed they had the necessary communication skills to be successful in their jobs.

The most effective contributors to managerial competency were experience, an aptitude for management, and having a mentor. Items rated least effective in improving management abilities included Professional Military Education courses and the System 100 and System 200 system acquisition classes.

AN ANALYSIS OF AIR FORCE ACQUISITION ENGINEERING OFFICER'S PERCEPTIONS OF THE ADEQUACY OF THEIR PREPARATION FOR MANAGEMENT

I. Introduction

General Issue

An important issue in today's Air Force is whether junior acquisition engineering officers are adequately prepared to meet the demands of their job assignments. The answer to this question is important for three reasons. First, if these officers feel they are poorly prepared for the job assigned to them or that the training they do have is being improperly utilized, then retention rates will be low and these assets will seek employment elsewhere (Kwon,1988:42). The second reason is that Congress believes acquisition personnel are inadequately trained and has mandated the establishment of a professional certification program. This mandate is embodied in Department of Defense (DoD) Directive 5000.52M to which the USAF is subject (Department of Defense, 1990). This opportunity should be used to truly improve the competence of acquisition personnel as well as to satisfy the dictates of Congress. Finally, the Department of Defense is in the midst of a substantial reduction in the size of the military forces. The Air Force must provide better preparation to acquisition engineering officers in order to

increase the productivity of those who remain (West, 1992:13).

Specific Problem

Readings on the subject of the transition from engineering to management indicated this issue is a major problem for industry (Howard, 1984:4; "Why...", 1983:4). Typically in industry, a successful engineer is made a project lead and continued success brings a promotion to program manager (Bayton and Chapman, 1972:5). This trial-and-error method of developing technical managers is increasingly unprofitable as industry becomes more complex and more competitive (Thornberry, 1988:67). The Air Force also operates in a very complex technical environment, but moves engineering and scientific officers into management positions even earlier in their careers than their civilian industry counterparts (Department of the Air Force, 1990; Hood, 1990).

This study will concentrate on the problem of moving Air Force acquisition engineers into management positions. Within the Air Force's acquisition career field the problem is large enough to have drawn the attention of the U.S. Congress. The Air Force has attempted to correct the deficiencies perceived by the Congress by implementing the instructions contained in DoD 5000.52M (Department of Defense, 1990). This research will investigate questions

relating to the adequacy of the engineer-to-manager transition process for Aeronautical Systems Center (ASC) engineering officers. It will also investigate those officers' perceptions of the benefits of management training in aiding this process.

Research Objectives

This study has three objectives. They are:

1) To determine if engineering officers are spending a substantial portion of their time performing management functions. For the purposes of this study, a substantial portion of time is defined to be 25% or more of an average workday.

2) To determine if engineering officers perceive their management training as adequate to meet the requirements of their jobs.

3) To determine which training efforts are the most effective contributors to managerial competence for engineering officers.

The intent is to meet these objectives by answering three research questions and several supporting investigative questions. The three general questions are:

I. To what extent are engineering officers performing management functions?

II. To what extent are engineering officers prepared to perform management functions?

III. To what extent are various training efforts contributing to engineering officers abilities to perform management functions?

Scope and Limitations

The population of interest is all USAF personnel assigned to acquisition engineering duties. The sample will be acquisition engineering officers assigned to ASC at Wright-Patterson AFB, Ohio. This study will not include engineering officers assigned to the various laboratories or to other non-acquisition positions at Wright-Patterson AFB. Also, those engineering officers assigned to Wright-Patterson AFB, but physically located elsewhere, such as Eglin AFB, Florida and Hanscom AFB, Massachusetts will not be included in this study.

There are two additional important limitations to this study. First, perceived competence will be measured, but no attempt will be made to measure competence directly. Secondly, although civilian engineers constitute a substantial portion of the acquisition engineering work force in the Air Force, this study will be limited to military officers.

Summary

In this chapter, the problem of the engineer-to-manager transition was introduced. Evidence was presented which indicated the USAF experiences problems with this transition process. The objectives of identifying the level of engineering officer involvement in management functions, determining the adequacy of engineer's management training, and identifying those training programs that are the most effective contributors to managerial competence were briefly introduced. Chapter two will present the results of a review of the literature from both the management and engineering disciplines concerning the engineer-to-manager transition process. Chapter three will discuss the research methods used in this project. The design and development of the two surveys used to collect data will be presented. The statistical tools used and the analyses performed to answer the research questions will also be discussed in this chapter. Chapter four will discuss the results of the data analysis. Finally, a discussion of the implications of the results will be contained in chapter five along with proposals for further research.

II. Literature Review

Introduction

The engineer-to-manager transition process has received a great deal of attention during the last two decades. The literature of both management and engineering disciplines contains numerous articles and studies on this topic. Because of the increasing complexity of our world compared to just a few years ago, industry is finding that it needs more managers with an understanding of the technology they manage.

> At the industry level, the assumption that "a manager is a manager is a manager" has met with strong challenges in the technical environment. The critical importance of engineering skill and knowledge is well recognized in the management of engineering systems." (Kocaoglu, 1984:33)

Companies in need of technical managers have not met with much success in teaching engineering to non-technical managers. This leaves promoting engineers to supervisory positions and eventually to management as the logical preference (Kocaoglu, 1984). Because of basic personality types and a lack of training, "a general myth has somehow evolved that engineers make poor managers" (Hoffman, 1989:3) and, "when you promote these people into management, in many cases, you lose a first-rate scientist or engineer and gain a lousy manager." ("Why...", 1983:4) The more prevalent view is not that engineers make poor

managers, but rather engineers are frequently poorly trained managers (Evans and Bredin, 1987:222).

Because of the high technology nature of the Air Force, it has the same problems with converting engineers into managers. This literature review addresses the selection of engineers for promotion to management or the transition of engineers to management. The first part of this review will address those articles that discuss the degree to which engineers are engaged in management. The second part will cover that portion of the literature that discusses the training needs of engineers in management. The third section of the literature review will address models of the engineer-to-manager transition process. A set of articles which proclaim the value of the new Engineering Management Degree programs in restoring the competitive edge within American industry through more effective and efficient management of highly technical projects will also be discussed.

Discussion of the Literature

Engineers In Management. Joseph Steger (1985:105) in his article on engineers as managers reports the findings of a 1978 survey of engineering graduates that revealed over 50 percent of the engineering graduates were in some sort of management position five years after obtaining

their last degree. In his book devoted to the subject of developing managerial skills in engineers Professor Badawy (1982:15) wrote that his research found 68 percent of engineers in the U.S. are employed as managers by the age of 65.

Even top-level management draws substantially from the ranks of engineers. In his article, "The Care and Feeding of Engineers," Mark Alpert (1992:87) reports that two-thirds of Chief Executive Officers (CEOs) of large Japanese manufacturing companies have engineering or science backgrounds. He despairs that "only" one-third of such firms in the U.S. have CEOs with technical backgrounds. In an article devoted to the topic of engineers as executives John Whittaker (1991, 5) compiles the results of several such studies. He discussed a 1990 *Business Week* study of CEOs in the top 1000 U.S. firms that discovered 35.7 percent of them had a first degree in engineering or science. That percentage varied considerably depending on the type of business. For example, less than 10 percent of CEOs in financial firms had backgrounds as engineers or scientists, while approximately 60 percent of CEOs in high technology firms and 45 percent of CEOs in telecommunication firms had engineering or science backgrounds. These numbers are similar to those Whittaker reported for a 1986 survey of *Fortune* 500 companies where 24 percent of the CEOs had a first degree in engineering.

Additionally, a 1990 Wisconsin School of Business study reportedly found that companies preferred executives with academic backgrounds as follows:

Engineering	33.1%
Marketing, Finance, Accounting	29.1%
Physical Sciences and Mathematics	21.4%
Liberal Arts	15.2%

Management Training of Engineers. Numerous articles suggest engineers are deficient in the skills or lack the traits of managers. These articles provide a foundation for understanding why engineers experience more than the usual difficulty moving into management positions. Ann Howard's article in *Research Management* reports the findings of more than two generations of data collected on Bell system college graduate managers in studies conducted at AT&T from 1956 to 1983. These findings indicate engineers are promoted more slowly than those who majored in humanities and social sciences because of weaknesses in administrative leadership and communications skills (Howard, 1984:4). She finds engineers are less effective in business situations that require making plans, creating order, or the developing novel solutions to business problems. When rated for middle management potential, 26 percent of the engineers were considered to have potential, compared to 46 percent of humanities/social science majors and 31 percent of business majors. Engineers also took an

average of 1.5 years longer to be promoted from first to second level management.

Ian Barclay (1986:253-260) conducted a study of technical managers in England using a mail survey from which he received 263 responses and selected follow-up interviews. The technical managers reported their number one problem in both frequency of occurrence and in severity was people management and the number two problem was industrial relations. Together, these two activities caused more problems than the other thirteen activities in the survey combined. Both activities depended heavily on interpersonal and communication skills. In the survey, the personal management skill identified as most likely to benefit from additional training was personal efficiency. Barclay found this to be at odds with the activities identified as causing the most problems. In follow-up interviews he found the reason for the frequent identification of personal efficiency as benefiting from additional training was that while many technical managers would admit to the need for additional training in various management skills, there was a general reluctance to admit to any deficiency in communication abilities (1986:257).

Two additional studies surveyed technical managers to determine the functions they performed and the relative frequency or perceived importance of those functions (Bayton and Chapman, 1972:11-16, 27-70; Hood, 1990:22-29).

The Bayton and Chapman study (1972) investigated the engineer-to-manager transition process in the NASA community. Hood (1990) surveyed engineering managers from first level to vice president level in many high technology companies throughout the world. These authors asked engineers promoted to management positions to identify their own training needs. Both of these studies identify written and verbal communication as the number one function and skill needing additional training for engineers to manage successfully.

Several studies (Evans and Bredin, 1987:223-225; Friesen, 1986:233-234; Hribar, 1985:37-38; Pettersen, 1991:22-24; Steger, 1985:105-106) presented the classical functions of management such as planning, staffing, organizing and controlling, then compared the activities and training of engineers to the management functions list to indicate where engineers needed additional training. Evens and Bredin (1987) identified two major issues concerning the transition from engineering to management. The first was a lack of management preparation for transitioning engineers and the second was the engineers' need to be more self-aware and to be aware of criteria and indicators for a successful transition. They also observed that engineers were often not required or inclined to take management courses and that "large proportions of engineers did not receive any training in some important managerial

tasks, particularly human relations skills." They also presented a table (Table 1) of the role differences between engineers and managers that points out where efforts should be expended in the transition process.

TABLE 1

ROLE DIFFERENCES BETWEEN ENGINEERS AND MANAGERS
(EVANS AND BREDIN, 1987)

Position	Focus	Approach to work	Problem solving	Achievement	Responsibilities	Basis	Effectiveness
Engineer	Scientific with things	Autonomous	Known procedures methods	Through the work itself	Specialist	Physical laws	Technical expertise
Manager	Traditional with people	Team oriented	Ambiguous initiative emotional	Through efforts of others	Generalist	Human behavior	Interpersonal skills

Friesen (1986) listed the primary management functions and then divided them into three categories: basic, administrative, and communicative. He then developed an algorithm that allows for a change in the mix of the three categories over the duration of a project and as an engineer advances through various levels from recruit to executive. Friesen proposed his algorithm as a guide to choosing a career path. He suggests that a self-evaluation of skills possessed can be compared to the skills mix required to determine the suitability of a position being considered.

Pettersen (1991), Steger (1985), and Hribar (1985) present lists of management functions and then invite engineers to compare their personal knowledge and

capabilities against the list. These articles are designed to enable engineers to take responsibility for their own career development and prepare themselves for managerial positions, if they so desire, through on-the-job training, self-study, and perhaps formal education.

Finally, Developing Managerial Skills in Engineers and Scientists (Badawy, 1982) is primarily a self-development tool. It devotes two of its eight sections exclusively to the engineer-to-manager transition process. Prof. Badawy highly emphasizes the need for a career development plan that includes both formal and informal management education.

Transition Models. Many models of management or technical management functions and skills exist, but models of the engineer-to-manager transition process are scarce. One model presented by Mandt emphasizes the necessity of a nurturing environment combined with a motivated employee in order to allow the acquisition of the required skills mix for successful management (Mandt, 1984:55). Figure 1 illustrates the concept. As someone progresses up through the levels of management, the role of the company and the immediate superior decreases and the employee responsibility for continued development increases. Figure 2 shows that, as an engineer progresses up through the management levels, the importance of his or her technical

and professional skills and even his or her interpersonal skills decreases until reaching the top levels of management where the need for managerial and administrative skills predominates.

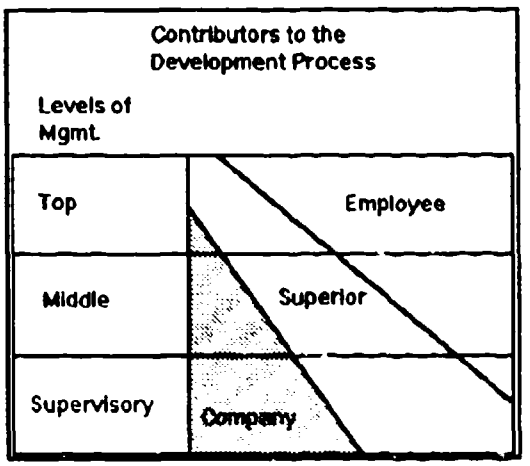

Figure 1. Mandt model of the development process for engineering managers (Mandt, 1984).

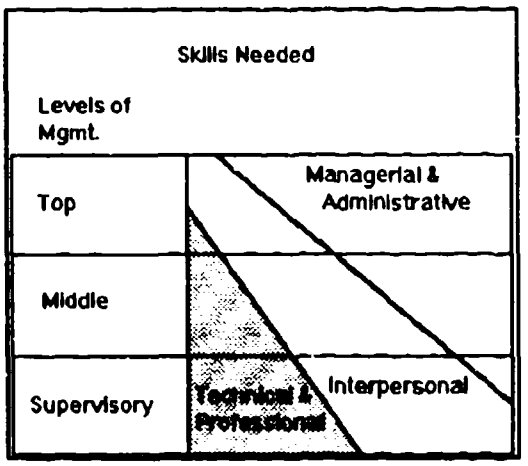

Figure 2. Mandt model of management skills requirements (Mandt, 1984).

The Mandt models are valuable because they closely reflect the published career progression plan for Air Force developmental engineers (Department of the Air Force, 1985:89-92).

Badawy (1982:15) says,

> "Managing is a task or an activity viewed as a *process* requiring the performance of several *functions* through the possession of a specific set of professional *skills* using certain *techniques*."

He developed a model very similar to Mandt's (Figure 3) in which requirements for technical skills decrease and the need for administrative skills increases as an engineer moves up the management levels. Badawy is a proponent of self-directed career plans that include both personal study and formal education.

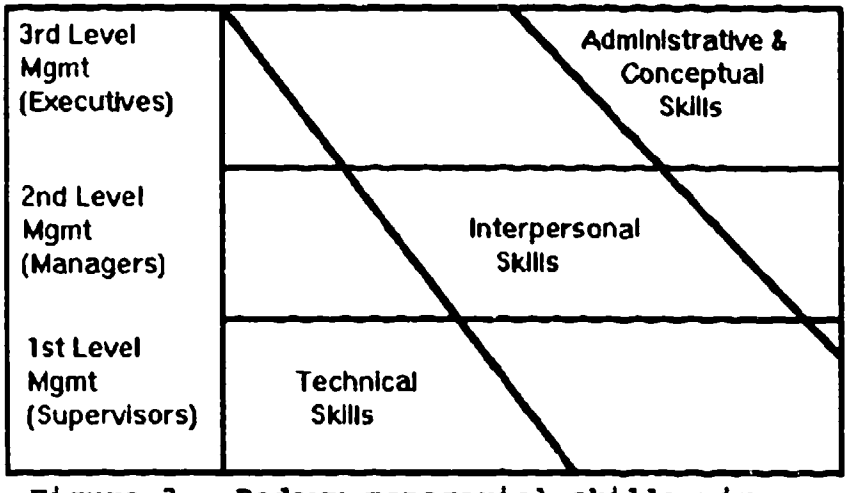

Figure 3. Badawy managerial skills mix (Badawy, 1990).

One additional article presented a transition tension model (Hall, Munson, and Posner, 1992:297). In developing this model the authors surveyed 260 engineers working full-time and also enrolled in an MBA program. Completed questionnaires from 132 people provided data on their objectives in obtaining an MBA. Data was also collected to determine employer expectations of their MBA seeking engineers and what types of assistance were provided to them. From this information the authors developed their transition tension model (Figure 4) that places employer, engineer, and university in an interactive team arrangement. This model illustrates the need for continual communication of desires, expectations, and requirements between all three parties in the model for a successful transition.

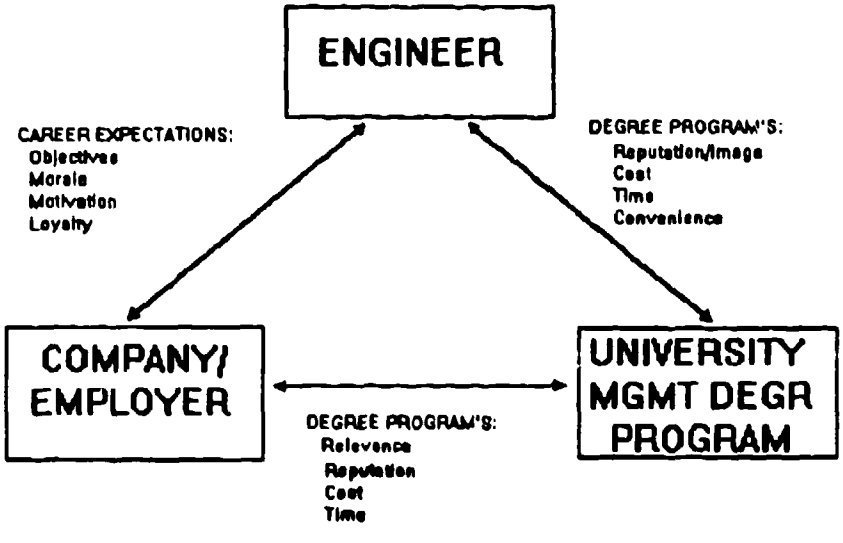

Figure 4. The transition tension model (Hall, Munson, and Posner, 1992).

Some of their notable findings include:

1.) Engineers enroll in MBA programs to enhance their value to both firm and career potential.

2.) Engineers do not perceive their employers as supportive of their efforts. Less than half of the employers take action to help the engineer succeed in an MBA program.

3.) Many employers do not even recognize employees that have completed an MBA program.

Engineering Management Programs. Conceptualizations of engineers as managers have evolved considerably in the last two decades. Early thinking such as, "promote and lose a good engineer and gain a lousy manager" as reported in *Management Review* ("Why...", 1983:4) has given way to:

> engineers promoted to management often encounter unique difficulties because of their particular level of training, background, personality traits, and experience . . it is recognized by most that some type of training is beneficial, if not essential, to facilitate the transition. (Koza and Richter, 1988:301)

In the last few years the evolution has continued, and now engineering management is a specialty considered essential to the industrial well-being of the nation, indeed even a "key to the future." (Sarchet 1989:4)

Engineers were first recognized as needing additional help and training relative to their peers with business and humanities backgrounds in order to succeed in management.

Management positions became the goal of many engineers who perceived management as a more prestigious and lucrative career path. Then, because of the increasingly technical nature of industry, managers with a technical background became a valuable commodity. This created a demand for personnel trained in engineering management, management of technology, engineering administration or related disciplines characterized by similar terms (Kocaoglu, 1984:38). This demand precipitated a worldwide doubling in the number of engineering management programs offered by institutions between 1970 and 1990 (Research, 1990:174). Whereas only one engineering management program, offered by the Massachusetts Institute of Technology, existed in 1913, there were one hundred twenty-one such programs in 1990 (Research, 1990:172). Engineering management has become an important multi-disciplinary sub-specialty of both engineering and management sciences. In fact, engineering management programs have become so numerous, so important, and cross so many specialties that the Accreditation Board for Engineering and Technology established guidelines for engineering management programs in 1989 (Wiebe and Babcock, 1989:27).

Sarchet (1989) reported on the success of the Engineering Management department he created at University of Missouri-Rolla in 1967. His first effort was to create an undergraduate program designed to graduate engineers

more capable of working through and with people to achieve corporate objectives. In addition to the usual engineering fundamentals, the program included courses in production, marketing, finance, personnel functions, and the fundamentals of dealing with people. The program was highly successful and had provided more than 1500 graduates by 1989.

The success of the undergraduate program led to the creation of a masters degree program in 1967 which also produced more than 1500 graduates by 1987. These successes led to the development in 1980 of a Ph.D. program in engineering management. The goal of this program was to provide professors for other institutions and programs. This program also gained popularity and graduated 12 students by 1989 with an additional 33 students actively enrolled in the program.

Engineers in the Air Force. In the civilian work environment an engineer who is satisfied with his or her position can generally remain in that position indefinitely. Those who choose to move into management will find many opportunities. One survey, "found that over 50 percent of engineering graduates were in management positions five years after attaining their last degree," (Steger, 1985:105) and the Engineering Manpower Commission determined that as many as 82 percent of all engineers in

the United States assume some form of a management role during their careers ("The Engineer...",1973).

Engineering officers in the Air Force are in a somewhat different position. The young junior officer engineer who is satisfied with a position providing technical support cannot become a Colonel providing technical support. From the day he or she is commissioned, that Lieutenant is groomed for promotion and that process consists largely of leadership training and acquisition specialty courses (AFR 36-23, 1985:89-92). The promotion system may provide a somewhat different incentive, but engineers in the Air Force, like their civilian counterparts, must move rapidly into management in order to have a successful career. In the Air Force, however, the move comes even earlier. Because the Air Force does not manufacture its own equipment or conduct much of its own research, Air Force engineers are employed mostly in the supervision and management of contractor personnel performing those functions. Hood's survey of a cross-section of engineering firms revealed that the average experience prior to a transition to a management function was 7.4 years (Hood, 1990:22). From the first day on the job, Air Force engineers may be performing management duties while their civilian counterparts are gaining several years of valuable experience in their specialties before moving into management.

The career progression guide for Air Force engineers contained in AFR 36-23 states with regard to management, "included is responsibility, commensurate with grade, for managing programs, projects, and activities established to perform development engineering pertinent to the specialty in this field." The chart that accompanies this statement shows that some portion of development engineers will have moved into the Acquisition Program Management career field by the four year point (Department of the Air Force, 1985:89,92).

In an attempt to answer Congress' criticisms of Air Force acquisition practices and recognizing the need for a formal development program for its acquisition personnel the Air Force has moved to comply with DoD 5000.52M (DoD, 1990). A portion of the stated purpose of DoD 5000.52M is to, "Improve the management and professionalism of the acquisition work force" (DoD, 1990:1-1). Three levels of development in eleven career fields are established by DoD 5000.52M (DoD, 1990:3-5, 3-6). Career progression plans and the minimum requirements for each of the three levels of development are presented. "At the intermediate level, specialization is emphasized (DoD, 1990:3-5)." An acquisition engineering officer can be qualified at Level II and be assigned to a mid-level management position without ever having had any formal management training.

Summary

That engineers are largely by inclination and training more introverted, less communicative, and more object oriented than graduates of business and humanities programs is a fact borne out by numerous studies. The impact of this deficiency is felt by industry when it moves engineers into management positions. Numerous articles reveal that corporations are moving more engineers into management to cope with the increasing complexity of modern product lines and as a result are more frequently encountering the problem of transitioning engineers to managers. Except for a few authors who advocate keeping engineers in engineering through the use of dual career ladders, the consensus seems to be that engineers make successful technical managers if additional training, especially in interpersonal and communication skills, is provided. Some of this training can be self-acquired, but the value of formal education is acknowledged by several authors. Some authors regard engineering management degree programs as highly beneficial to corporate employers of technical managers. The preponderance of the literature indicates substantial benefits to business in imparting management skills to engineering managers. The Air Force is such a large user of high technology that it should also benefit extensively from a comprehensive program of management training for engineers.

III. Method

Overview

This chapter describes the method employed in this research. The objective of the research will be reviewed first. Then the research classification will be addressed. Following that, this chapter will describe both the population of interest and the sample. Survey development and the survey pretest will be described next. Then, validity will be addressed briefly. Finally, each of the three primary research questions with the supporting investigative questions and the data analysis methods used to answer each of them will be described.

Objectives

The three objectives of this research are:

1) To determine if engineering officers are spending a substantial portion of their time performing management functions. For the purposes of this study, a substantial portion is defined to be 25% or more of an average workday.

2) To determine if engineering officers perceive their management training as adequate to meet the requirements of their jobs.

3) To determine which training efforts are the

most effective contributors to managerial competence for engineering officers.

Research Classification

This research is a field study with a one-time collection of data by means of two mail surveys. It is exploratory and descriptive in nature because the primary purpose of this research is to identify relationships among the study variables, not to predict them. Analysis by descriptive statistics and nonparametric statistical tests will support answers to the research questions.

Population

As previously indicated, the population of interest for this study was Air Force Acquisition Engineering personnel. The junior officers of ranks 2nd Lieutenant, 1st Lieutenant, and Captain were of particular interest as they were most likely to be converting from engineers to managers. Senior officers were also included because they possess insights into the transition process based on their experiences. There were 2820 acquisition engineering officers in the Air Force stationed throughout the world at the time of the survey (Gout, 1993).

Sample

The sample for this study consisted of all acquisition engineering officers assigned to ASC at Wright-Patterson AFB, Ohio (WPAFB). This sample was presumed representative of all engineering officers in the Air Force. ASC is the largest of the Air Force product centers and employs the most engineering officers at any one time. The majority of acquisition engineers are assigned to WPAFB at least once in their careers. Additionally, Captain Pearson's (1989) research indicated the assumption that WPAFB engineering officers are representative of all Air Force engineering officers is reasonable, at least for junior officers.

A total of 637 engineering officers (Rollins, 1993) were assigned to WPAFB at the time of the survey. Many of these officers were assigned to the various laboratories and organizations other than ASC at WPAFB and some were collocated at operational organizations and the other acquisition centers for liaison purposes. ASC actually employed 280 officers in acquisition engineering positions at WPAFB (Carpenter, 1993) in the September to November 1993 period in which this survey was conducted. This number was nearly ten percent of the 2820 acquisition engineering officers that constitute the population of interest. As with the population, the group of primary interest was junior officers - lieutenants and captains, with the engineering job specialty code, but senior officer

engineers were also surveyed in recognition that most of them have completed the transition to management and should have valuable insights regarding the process. Figure 5 displays the relationships between the population and the sample.

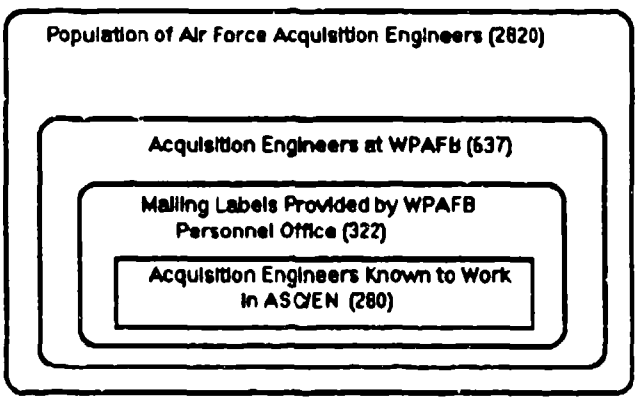

Figure 5. Relationship of sample to population.

Each of the engineers in the sample was mailed a survey designed to obtain the desired research data and demographic information. The survey instrument was kept to a minimum in size to encourage a maximum response.

A second survey was created for the supervisors of those engineers receiving the first survey. The supervisor survey consisted of a small subset of the questions addressed to the engineers. It's purpose was to obtain feedback for the research sponsor regarding supervisor satisfaction with the engineers provided to them by ASC/ENO

and to provide a means to validate the responses given by the engineers.

Survey packages were sent to a list of 322 ASC acquisition engineers and their supervisors. The Wright-Patterson AFB Consolidated Base Personnel Office (Rollins, 1993) provided a list of acquisition engineers and mailing labels for the engineers and their supervisors. The mailing and responses of the engineer's survey by rank are shown in Table 2.

TABLE 2

NUMBER OF SURVEYS MAILED AND RETURNED BY RANK

Rank	Surveys Mailed	Surveys Returned
2nd Lieutenant	31	25
1st Lieutenant	22	13
Captain	196	134
Major	42	24
Lieutenant Colonel	27	17
Colonel	4	2

Each engineer was sent a survey package with a cover letter signed by the sponsor in ASC/ENO soliciting a response, an instruction sheet, the survey with an answer sheet, and a pre-addressed return envelope. The supervisor of each engineer was sent a similar package with the cover letter modified to explain the need for a response from the supervisor of each survey recipient and an abbreviated survey. The response rate for the engineer's survey was

66.8% and the response rate for the supervisor's survey was 67.7%. These response rates were considered satisfactory and no attempt was made to increase the number of responses with follow-up letters or other similar means. These response rates were also relative to the 322 surveys mailed out. Due to limitations in the sorting process for mailing labels, some officers now working other positions but still holding a secondary job specialty code for engineering were sent a survey. The survey cover letter however explained who was being asked to respond. When considering only the 280 acquisition engineers known to have been working for ASC/EN at the time of the survey, the response rates were 76.8% and 77.9% for engineers and supervisors respectively. The list of survey recipients was not retained after the mailing, but answer sheets of engineers and their supervisors were numbered in pairs to facilitate assessment of the validity of engineer responses. The engineer responses by rank are also shown in Table 2. As can be seen in Figures 6 and 7, the response rates were reasonably uniform across the various ranks. From the 322 supervisor surveys mailed, 218 were returned. From among the 218 returned surveys, responses from 158 could be paired with responses from engineers that worked for those particular supervisors.

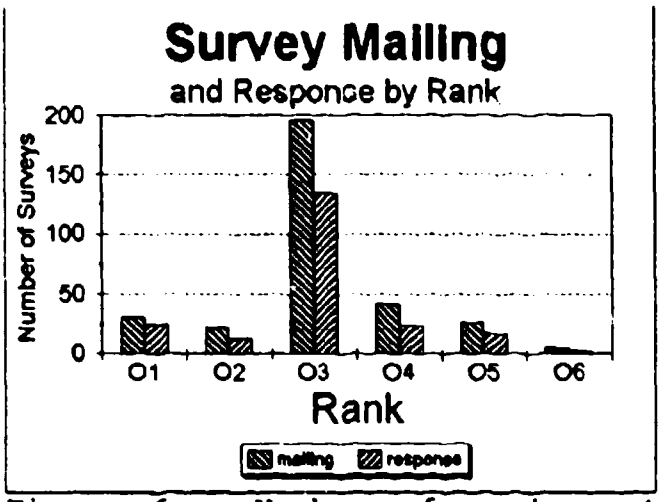

Figure 6. Number of engineers' surveys mailed and returned by rank.

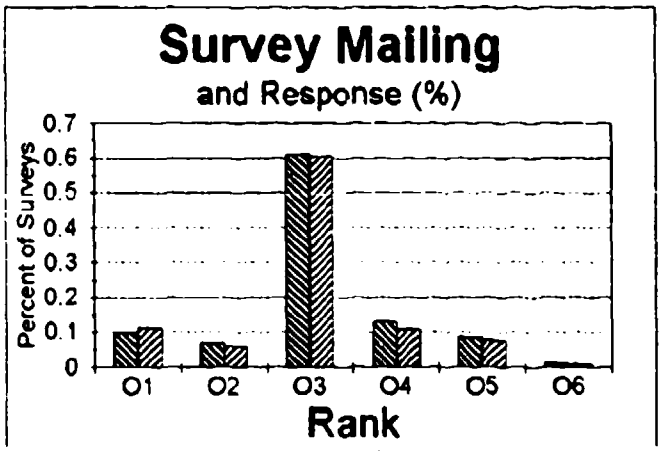

Figure 7. Percent of surveys mailed and returned by rank.

Survey Development

Data was collected by means of two mail surveys. This method was chosen primarily because it tends to be more efficient and economical than many other collection methods. An additional selection factor was the probability of higher response rates due to the anonymity

factor of a mail survey (Emory, 1985:198). A further attempt to increase response rate was made by designing the survey instruments to be as short as possible.

The engineers' survey instrument contained 43 questions in four areas. Several papers from the civilian sector, (Bennett and McMullen, Hood, and Barclay) and from the Air Force, (Baumgardner, Pearson, and Wilson) provided sample formats and questions for use as models in constructing this survey. The first section of the survey instrument contained twelve demographic questions such as rank, Air Force Specialty Code (AFSC), undergraduate degree specialty, and number of years worked in acquisition positions. The second section included four questions designed to measure the extent to which acquisition engineering officers were performing management functions. The eight questions in section three determined the degree of adequacy of management training and education. The fourth and final section, composed of nineteen questions, was designed to determine which experiences, training courses, and job requirements were the most effective contributors to managerial competence in engineers. The complete survey instrument is presented in Appendix A.

Several strategies were used to improve the quality of the survey instrument during its development. The first strategy was to use, to the greatest extent possible, the format and questions from previous research with

demonstrated results. Pre-testing a draft version of the survey instrument was the second strategy. An additional strategy was to obtain a survey control number from the Air Force Military Personnel Center (AFMPC) so survey recipients would know the research was officially sanctioned and hence would take the survey seriously. AFMPC/DPMYAS (Neaville, 1993) reviewed the draft survey instrument prior to issuing a control number and provided several helpful critiques. Another strategy used to improve both the quality and the percentage rate of responses to the survey was to obtain a local sponsor for the research that would find the topic relevant to his or her job responsibilities and who would possess authority to act on the survey results if indicated. The Engineering Operations Division of ASC (ASC/ENO) was contacted, and the Coordinating Manager for Military Acquisition Resources agreed to sponsor the research. Finally, a second survey instrument was sent to the supervisors of the engineers that received the first survey. It was assumed that engineers would take more care in answering questions and produce higher quality results if they knew their supervisors were completing a similar survey.

Demographic Data. The demographic section of the survey was designed to gather background information on each respondent. The first item asked for rank and

possible responses were 2 Lt, 1 Lt, Capt, Maj, Lt Col, Col, and Other. Similar questions about AFSC (a list of nine options consisting of the engineering specialty codes 2816, 2825, 2835, 2845, 2855, 2865, 2875, 2895, and Other), gender (male or female), and level of Professional Military Education (PME) completed (SOS, ISS, SSS, Other, and None) followed. Additional questions asked for commissioning source (ROTC, OTS, USAFA, and Other), acquisition experience (Less than 3 years, 3 years but less than 8 years, and 8 years or more), and undergraduate degree specialty with options for Electrical, Mechanical, Civil, Industrial, Chemical, and Astronautical Engineering plus Other (Specify). The remaining four questions in the demographic section asked for Acquisition Professional Development Program (APDP) certification levels in both technical and management areas and for the number of credit hours contributing to competency in technical and managerial functions. The APDP certification questions had options of, I have not applied, Level 1, Level 2, and Level 3. Technical credit hour response options were, Less than 25 credit hours, 25 but less than 50 credit hours, 50 but less than 90 credit hours, 90 but less than 120 credit hours, and 120 or more credit hours. Management credit hour response options were, Less than 5 credit hours, 5 but less than 10 credit hours, 10 but less than 40 credit

hours, 40 but less than 70 credit hours, and 70 or more credit hours.

Involvement in Management. In this section of the survey, respondents were asked first to indicate the percent of time on a daily basis which was spent in performing traditional management functions such as planning, controlling, directing, scheduling, budgeting, and staffing. The options were less than 10%, 10% but less than 25%, 25% but less than 50%, 50% but less than 75%, or more than 75%. The remaining three questions in this section asked for the level of activity for three specific management functions, directing the activities of others, budgeting, and planning. Possible answers for these questions were "Daily", "2-3 times per week", "Weekly", "Monthly", "Quarterly", and "Less than quarterly or not at all".

Adequacy of Management Preparation. The first two questions in this section asked the responding engineer to rate the adequacy of his or her preparation by training or education for managerial responsibilities and also to rate his or her managerial skills. Respondents were provided a four-point ordinal scale ranging from "Poor" through "Fair", "Good" and "Excellent." Six additional questions requested an evaluation of personal perceptions about

ability to perform managerial functions. The response scale is shown in Figure 8.

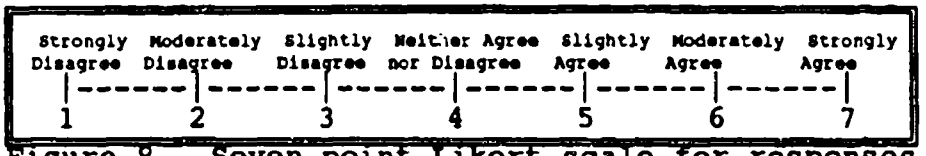

Figure 8. Seven-point Likert-scale for responses to engineer survey questions 19 to 24.

Effective Contributors to Managerial Competency. This section of the survey contained two parts. The first part asked each engineer to rank order a list of nine items according to his or her perceptions of how much each one contributed to his or her ability to manage effectively. The nine items were managerial experience, innate talent, masters degree, Squadron Officers School, other PME, having a mentor, Systems 100/200 (introductory and intermediate systems acquisition courses), and finally acquisition experience. Part two of this section measured the level of contribution to managerial expertise for the items above, and added an item for satisfying APDP requirements. Questions in this part were answered with the six-point ordinal scale shown in Figure 9.

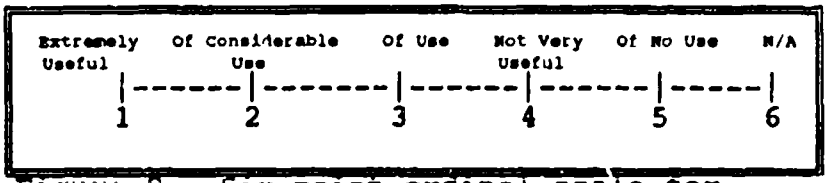

Figure 9. Six-point ordinal scale for responses to engineer survey questions 34 to 43.

The supervisor's survey was created as a way to verify some of the more important responses provided by engineers when answering their survey. It was also a way to collect data and provide feedback to the research sponsor about the quality of engineers being provided to ASC program offices. The supervisor's survey was composed of seven questions, all of which were answered using the same seven-point Likert-scale used in the Adequacy of Management Preparation section of the engineer's survey (Figure 8). Six of the questions were the same as those from the engineer's survey slightly reworded to ask the supervisor's opinion of his or her employee's managerial skills. The seventh question asked the supervisor if the engineer spent a substantial portion of time performing management functions. A "substantial portion" was defined in the question as more than 25% of an average workday. The complete supervisor survey instrument is presented in Appendix B.

Survey Pretest

As part of the survey development process, a draft of the survey was used to conduct a pre-test of the survey instrument. Ten Air Force Institute of Technology (AFIT) graduate students who possessed recent acquisition engineering experience participated in the survey. Those officers were instructed to complete the survey as if they were still in their previous jobs. The comments provided

by the participants were very helpful in improving both the format of the survey and the survey questions.

Validity

As with any data collection instrument, validity is a primary consideration. The issue of validity is an important one in a mail survey, especially when respondents are asked for a self-assessment. A common concern is that respondents to self-assessment questions will have provided inflated ratings. This, as reported in the section on survey development, was one of the reasons for the development of the supervisor survey. The responses to the three specific management function questions common to both the engineer and supervisor surveys: organizing teams, directing teams, and communicating were evaluated with the Spearman Rank Correlation Test. The purpose of this test was to one, check for a relationship between each engineer's self assessment and the corresponding assessment of the supervisor as a verification of engineer responses, and two, to investigate the existence of inflated self-assessments on the part of engineers. Spearman Rank Correlation coefficients were calculated on the 158 response pairs where both the engineer and his or her supervisor returned valid survey answer sheets. The correlation coefficients indicated that the responses from engineers and their supervisors for the three questions

about organizing teams, directing teams, and communicating are not correlated. The test results are shown in Table 3. Figure 10 shows the general trend of the responses for the three management functions. Figure 11 displays the top three, (affirmative), responses and shows that engineers more frequently slightly agreed or moderately agreed they were good at organizing, directing, and communicating then did their supervisors, but the supervisors more frequently strongly agreed than did the engineers. The histograms indicate that the engineers did not tend to inflate their responses. While the supervisors' responses were not correlated with engineers' responses, the general positive assessment by the supervisors provides strong indication that engineers are performing adequately.

TABLE 3

TEST FOR ENGINEER-SUPERVISOR CORRELATION

Management Functions	Spearman Rank Correlation Coefficient
Does a good job organizing teams	.07
Does a good job directing teams	.19
Has the communication skills to be successful	.08

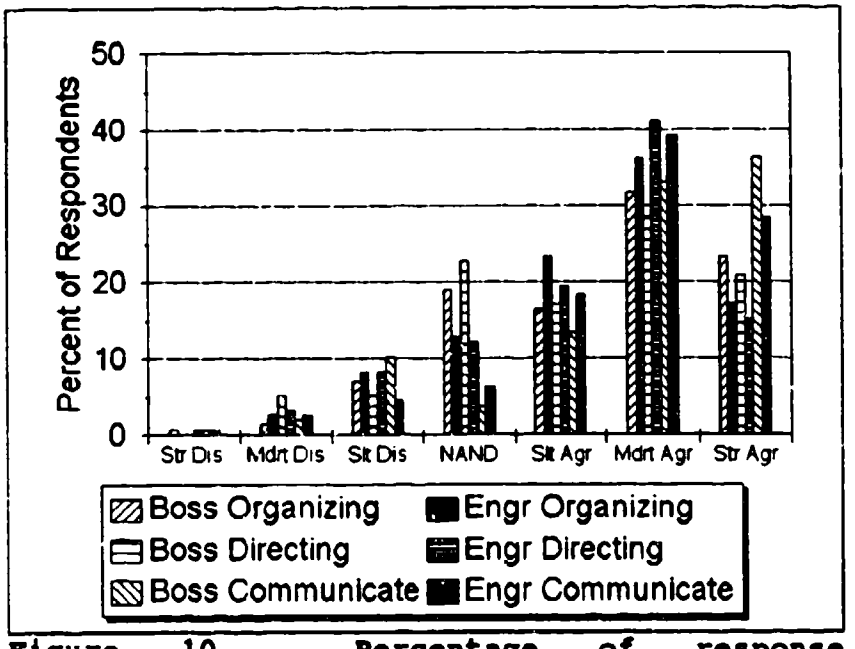

Figure 10. Percentage of response distributions for supervisor and engineer evaluation of management function skills.

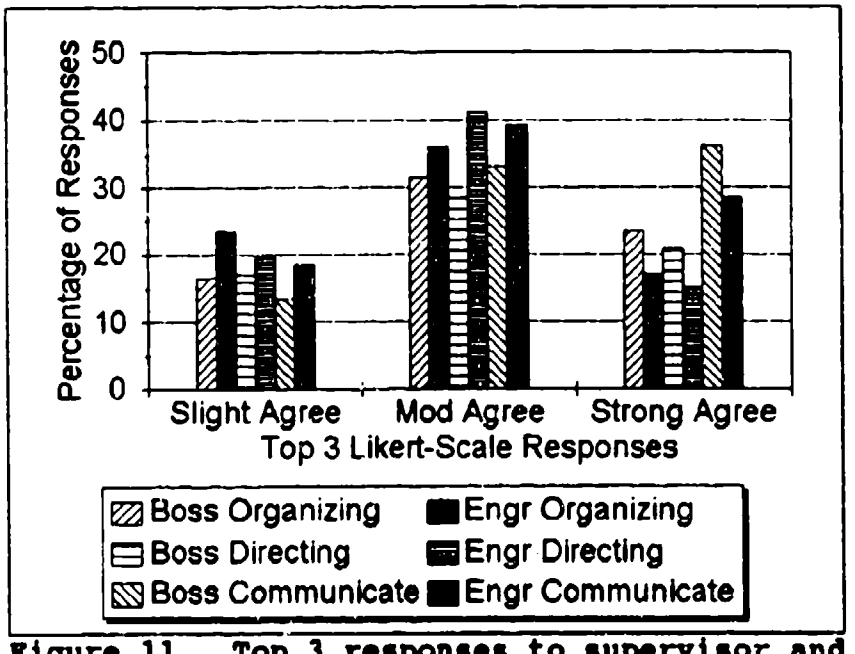

Figure 11. Top 3 responses to supervisor and engineer evaluations of management function skills.

The demographic questions produced data readily verifiable from other sources, but a recent study similar to this one reported no evidence of measurable differences between available records and survey responses, (Baumgardner, 1991:92), so no effort was made to verify the demographic data. It was assumed that a similar sample responding to similar questions would respond in a like manner for this study. The remaining question was that of nonresponse bias. Among the various factors that might influence a group not to respond and thus bias the data such as: rank, AFSC, educational background, job experience, and personal feelings about the research topic, the factor that was most readily measurable was rank. As was shown in Figure 7 in the section describing the sample, the percentage of surveys mailed by rank was not significantly different than the percentage of surveys returned by rank. If the response rate did not vary by rank then the nonresponse group was not biased by rank.

Research Questions and Data Analysis

Research Question I: To what extent are engineering officers performing management functions? This question was answered directly by asking engineers to indicate the percent of time spent during an average workday performing management functions. The analysis of the response to this

question was confined to descriptive statistics and a histogram. Supervisors were asked if their engineers spent at least 25% of an average workday performing management functions. The supervisor responses were also analyzed with descriptive statistics and a histogram. This research question was also supported by two investigative questions.

Investigative Question 1A: Do senior officers spend more time managing than junior officers? The responses for the survey question about time spent managing were used to answer this question using descriptive statistics and a 3 x 5 contingency table. The contingency table for rank versus management time was constructed in a spreadsheet program using procedures described by Conover (1980: 153-167). To ensure adequate frequencies in each cell of the table, respondents were placed in three groups, Lieutenants (O1 and O2), Captains (O3), and senior officers (O4, O5, and O6) for row entries. The column entries were the five response levels for the amount of time spent managing. Table 4 provides an example.

The hypotheses for use with this table were;

> H_o: All the probabilities in the same column are equal to each other.
> H_a: At least 2 of the probabilities in the same column are not equal to each other.

The test statistic T is then calculated in the spreadsheet and if $T > T_{(1-\alpha),}$ the Chi-square random variable with (r-1)*(c-1) degrees of freedom, then H_o is rejected in

favor of H_a. In this case $T_{(1-\alpha)}$ for (3-1)*(5-1) = 8 degrees of freedom was 15.51 (Conover, 1980:432). A value of T greater than 15.51 would indicate that officers of different ranks had indeed indicated they spent different amounts of time performing management functions. Note the test statistic T is Conover's notation for χ^2 in his description of the contingency table test and χ^2 will be used from this point on to report test values.

TABLE 4

SAMPLE CONTINGENCY TABLE

	Class 1	Class 2	Class 3	Class 4	Class 5	
O1 & O2	$O_{1,1}$	$O_{1,2}$	...	...	$O_{1,c}$	n_1
O3	$O_{2,1}$	$O_{2,2}$	...	...	$O_{2,c}$	n_2
O4,O5,O6	$O_{r,1}$	$O_{r,2}$	...	...	$O_{r,c}$	n_3
Totals	C_1	C_2	...	...	C_c	N

Investigative Question 1B: How frequently do engineers perform traditional management functions? This question provided a cross-check of the question about time spent in performing management functions. Three questions asked how frequently the engineer engaged in planning activities, directed the activities of others, and engaged in budgeting activities. These questions were analyzed with descriptive statistics.

Research Question II: To what extent are engineering officers prepared to perform management functions? Four investigative questions were used to determine engineering officers' perceptions regarding this question.

Investigative Question 2A: What level of management education are engineering officers receiving? One question requested the number of credit hours accumulated in management related courses, and for comparison purposes, another question asked for the number of technical related credit hours. These results were evaluated with descriptive statistics. Contingency tables were constructed to investigate the impact of management training on responses to questions about managerial skills, personal expectations for managerial expertise, and evaluation of communication skills. The five levels of possible answers for the number of credit hours formed the rows in the contingency tables and levels of response for management skills formed the columns.

Investigative Question 2B: How do engineers rate their management training? For this question engineers were asked to rate how well the training they had received prepared them for managerial responsibilities using responses of "1" for "Excellent", "2" for "Good", "3 for "Fair", and "4" for "Poor." Descriptive statistics were

used for the analysis, and a 3 x 4 contingency table was used to analyze the responses for variations by rank. The rank groupings formed the table rows and the rating of the quality of training received formed the columns of the table.

Investigative Question 2C: How do engineers rate their management skills? A single question asked engineers to characterize their managerial skills in general using responses of "1" for "Excellent", "2" for "Good", "3" for "Fair", and "4" for "Poor." The results were analyzed with descriptive statistics and a histogram. A contingency table was also used to determine if there was a difference in skills rating due to rank. Rank groups again formed the contingency table rows and the possible ratings for skill formed the columns. Engineers were asked to assess their abilities as managers in three areas using a Likert-scale with values ranging from "1" for "Strongly Disagree" to "7" for "Strongly Agree" (Figure 8). Results were analyzed with descriptive statistics and a histogram.

Investigative Question 2D: Does the perceived adequacy of training in preparation for managerial responsibilities vary as a function of personal characteristics? Three separate tests were performed by use of r x c contingency tables with the ratings of training received as the column

entries and the various commissioning sources, time on the job entries, and masters degree selections as row entries respectively.

Research Question III: To what extent are various training efforts contributing to engineering officer's abilities to perform management functions? Two investigative questions were used to answer this question.

Investigative Question 3A: From the provided list of items, which contribute most to managerial competency? Nine survey questions constituted a list of items that potentially contribute to managerial competence. Engineers were asked to rank order the list by placing a relative rating from one to nine as the answer to each of these questions. A Friedman nonparametric two-way analysis of variance was performed on the list of contributors related to these nine factors to determine relative order of importance. The Friedman analysis was then performed on pairs of factors to establish groups of contributors that were statistically indistinguishable from their neighbors in the list of contributors.

Investigative Question 3B: Are APDP requirements important contributors to managerial competence relative to other items? The answer to this question comes from the analysis performed for investigative question 3A. The Friedman test determined if the difference in ranks is statistically significant. The position of the APDP requirements within the list of possible contributors establishes their value as a contributor relative to the other items.

Summary

This chapter has described the research classification. The population of interest and the sample were also discussed. Development of the survey was presented along with the efforts made to measure validity. Finally, the research questions were presented along with the data analysis methods used to answer each one. The next chapter will discuss the analytic results.

IV. Results

Introduction

This chapter presents the results obtained from applying the data collection and analysis methods described in Chapter III. Observations about the data, descriptive statistics, and nonparametric statistical tests are used to answer the questions posed in this study.

Research Questions, Tests and Associated Findings

Research Question I. To what extent are engineering officers performing management functions? Sixty-eight percent of ASC engineering officers surveyed spend more than 25% of their time in an average workday performing management functions. It's interesting to note that across all the ranks, including the lieutenants, 51.7% of engineering officers reportedly spend more than 50% of an average workday performing management functions (Figure 12). Additionally, almost 75% of senior engineering officers are spending more than 75% of their time managing. The results of the supervisor survey corroborate these findings. Sixty-eight percent of the engineers' supervisors indicated agreement to some extent that their engineers spend at least 25% of their time performing management functions.

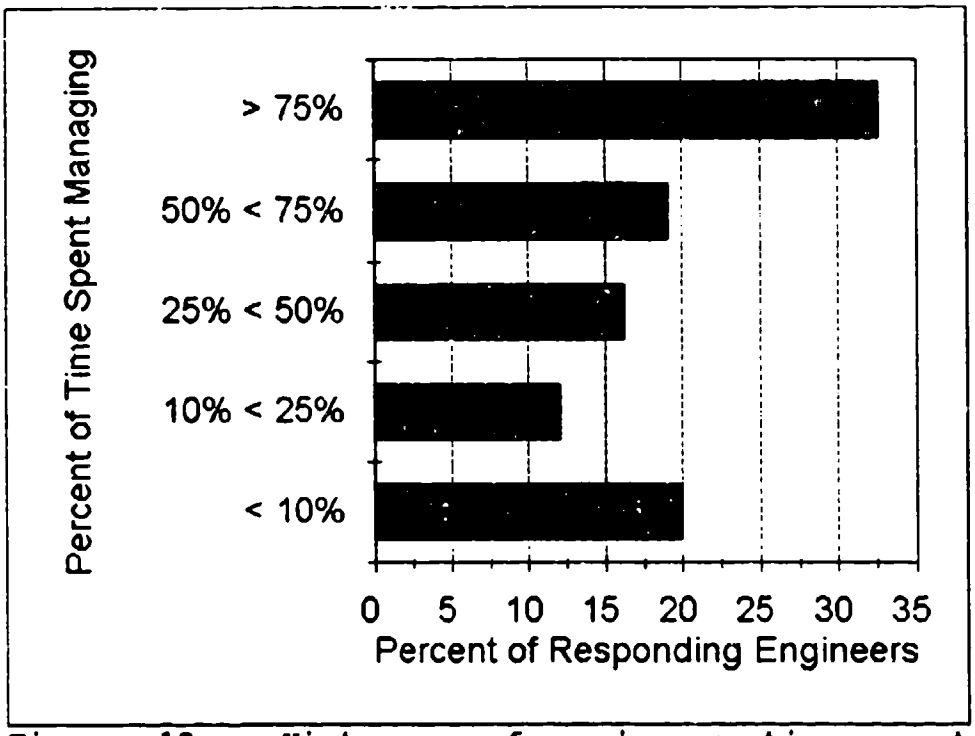

Figure 12. Histogram of engineers time spent performing management functions.

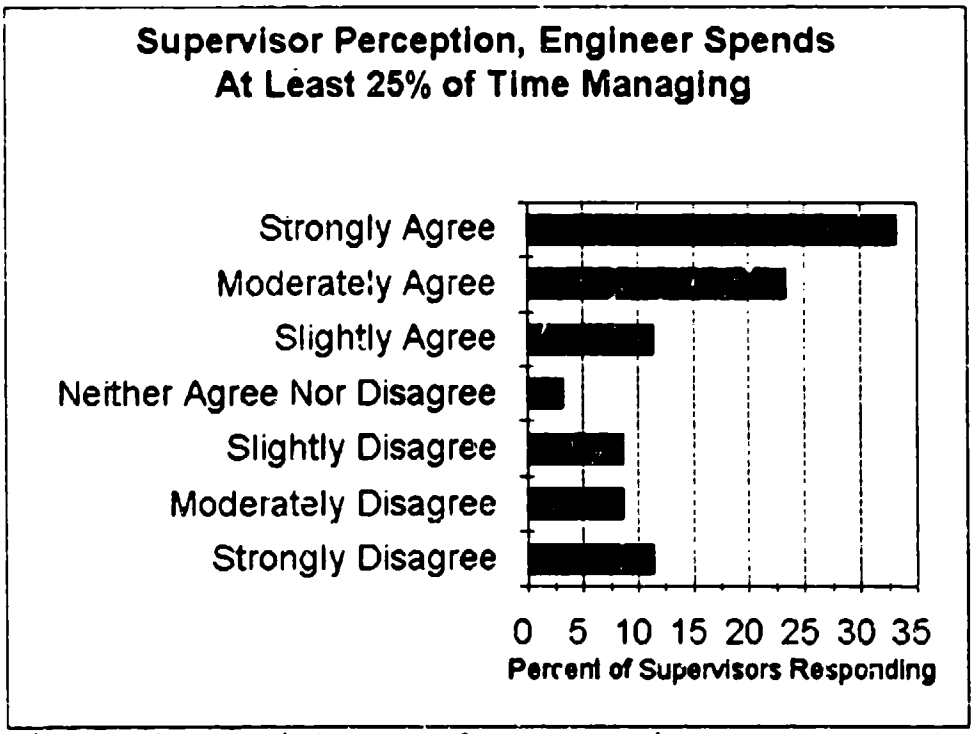

Figure 13. Histogram for supervisor response to engineer spends more than 25% of time managing.

Investigative Question 1A. Do senior officers spend more time managing than junior officers? This study indicates that there is a difference in the amount of time dedicated to management functions between various ranks (χ^2=44.46, $(\chi^2)_{d.f.=8,\alpha=.05}$=15.51). The proportion of time spent managing is illustrated in Figure 14. A review of this figure shows that the proportion of engineers who spend more than 75% of the time managing increases as they progress through the higher ranks. Further examination reveals that by the time engineers have reached the rank of captain, 53.4% reported spending more than 50% of an average workday performing management functions.

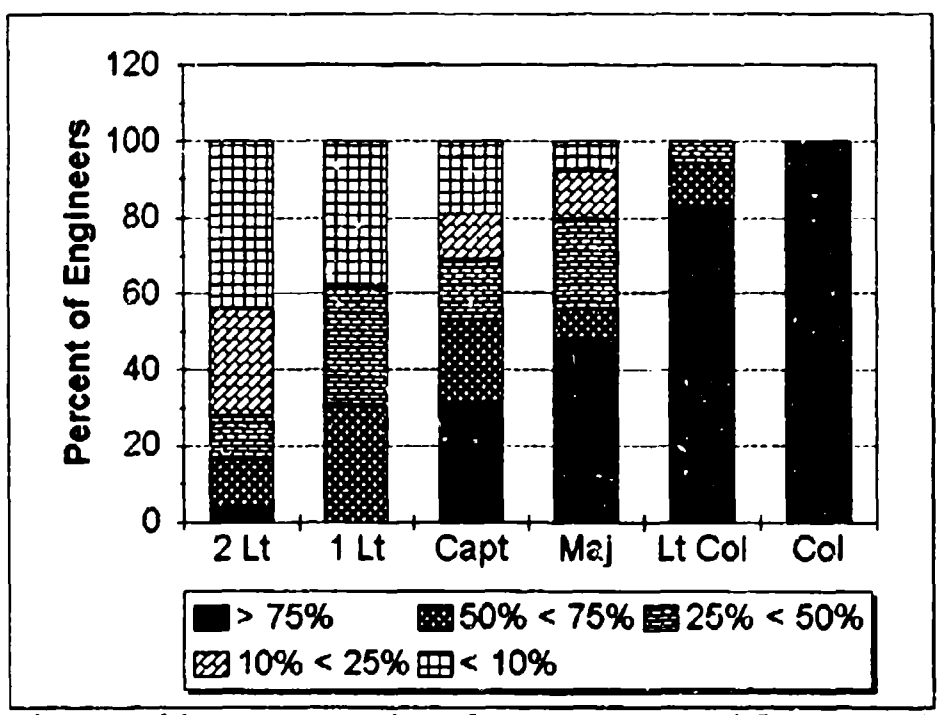

Figure 14. Percent of average workday spent performing management functions by rank.

Investigative Question 1B. How frequently do engineering officers perform traditional management functions?

Planning. The engineers surveyed are frequently called upon to participate in planning activities. Over 70% of the respondents indicated they participate in planning activities on a weekly basis or more frequently. Less than 10% of the respondents indicated they participate in planning less frequently than quarterly (Figure 15).

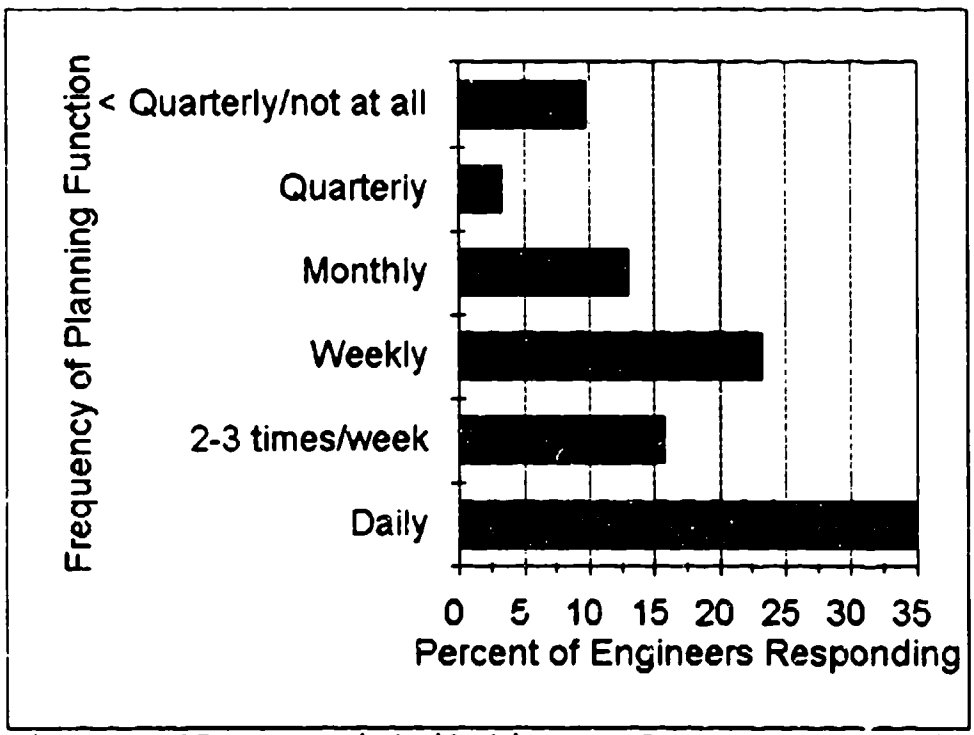

Figure 15. Distribution of responses to participation in planning function.

Directing. The engineers surveyed are frequently called upon to direct the activities of others. Sixty-

eight percent of the respondents indicated they engaged in the management function of directing others on a weekly basis or more frequently. Less than 20% of the respondents indicated they participate in directing the activities of others less frequently than quarterly (Figure 16).

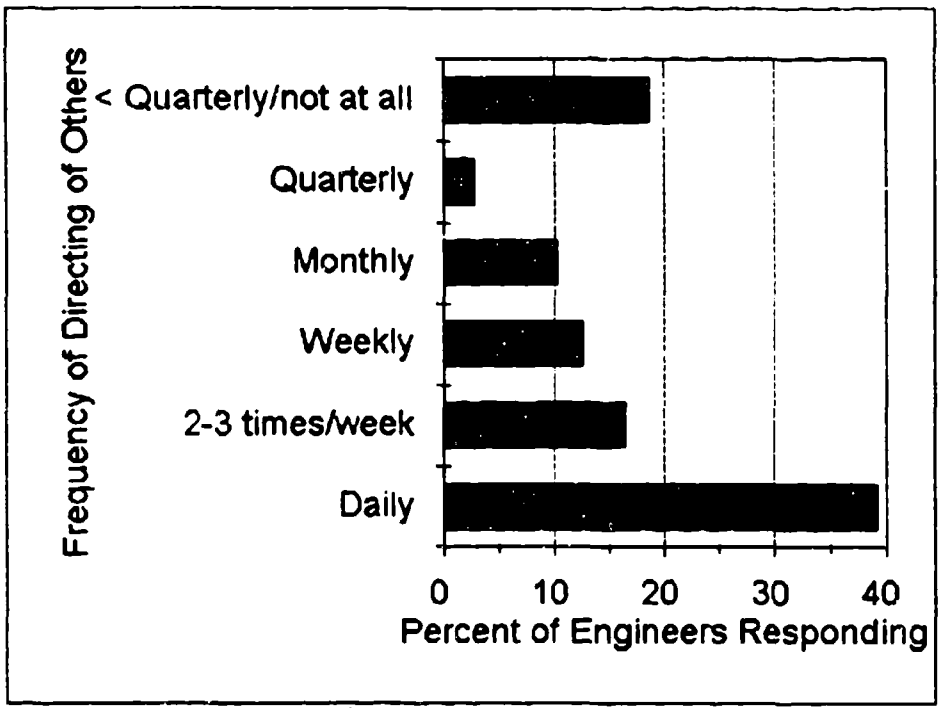

Figure 16. Distribution of responses to participation in directing others.

Budgeting. Another of the traditional management functions that engineers participate in is budgeting. In contrast to the functions of planning and directing, relatively few engineers indicated that they participate regularly in budgeting activities. Less than 25% of the responding engineers indicated they participate in budgeting activities any more frequently than weekly. More

than 43% indicated they had engaged in budgeting activities less than quarterly or not at all (Figure 17). The results for the question about budgeting may indicate that the budgeting function is more compartmentalized than other management functions in Air Force acquisition.

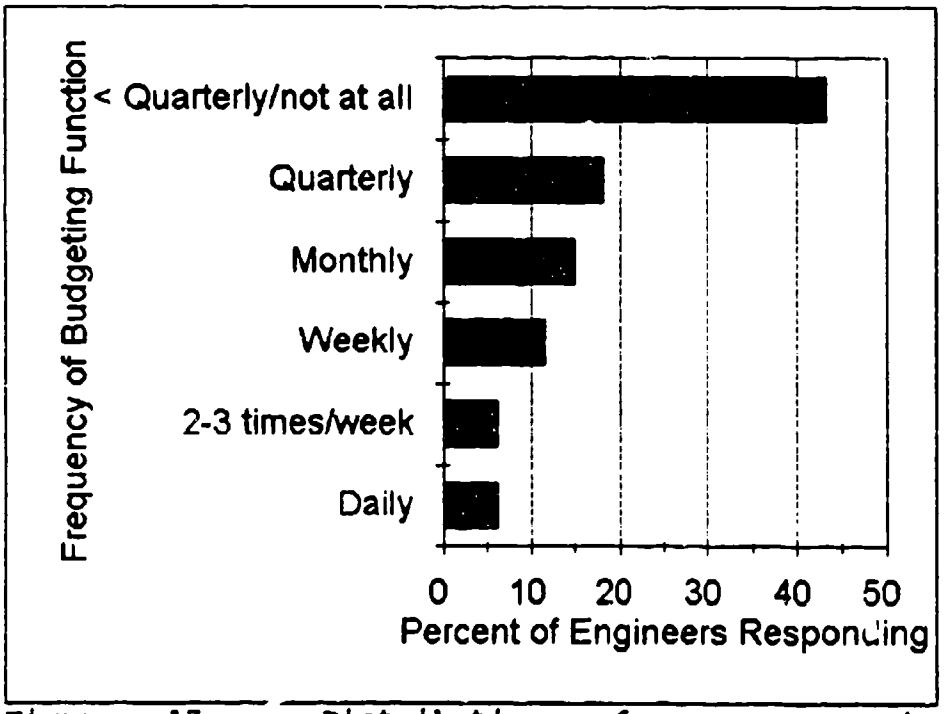

Figure 17. Distribution of responses to participation in budgeting function.

Research Question II. To what extent are engineering officers prepared to perform management functions?

Investigative Question 2A. How do engineers rate their management training? A majority (53%) of engineering officers indicated their training for management was "Good"

or "Excellent." Less than 15% of the responding officers described their management training as "Poor" (Figure 18). There was no difference in perceptions of the adequacy of management training between officers of different rank (χ^2=11.24, $(\chi^2)_{d.f.=6,\alpha=.05}$=12.59).

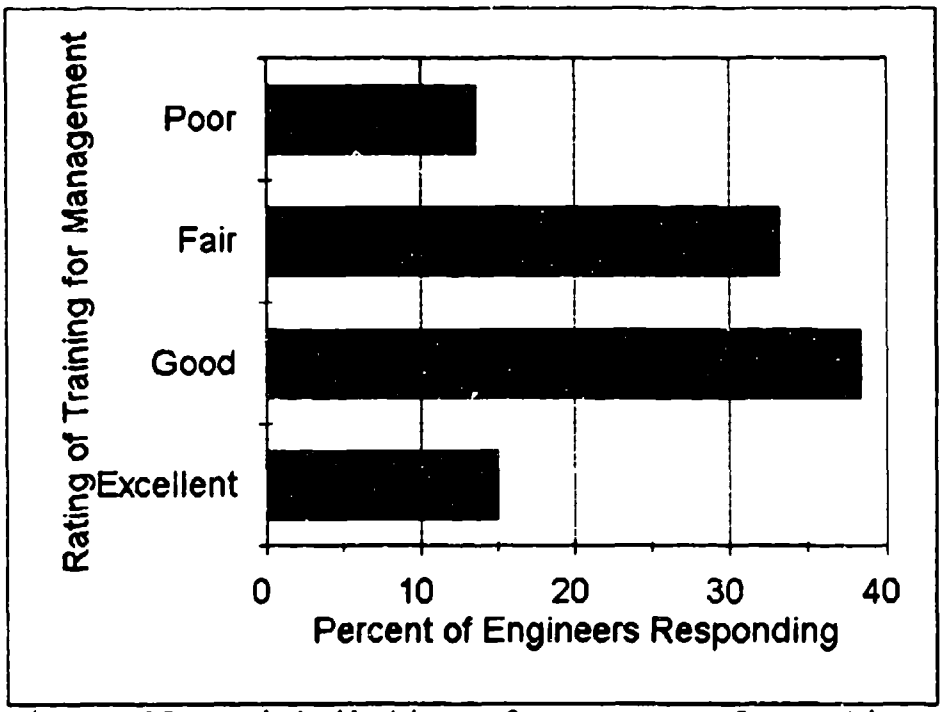

Figure 18. Distribution of responses for ratings of management training.

Investigative Question 2B. How do acquisition engineers rate their management skills? An alternative approach to determine how adequately engineering officers were prepared to perform management activities was to determine the extent to which they possessed managerial skills. Over 72% of engineering officers indicated that

their managerial skills "in general" were "Good" or "Excellent" (Figure 19). Out of 215 survey respondents, there was not a single officer who indicated that his or her management skills were "Poor." A comparison of self-assessed managerial skill among ranks demonstrates there is a difference in the level of competence reported between officers of different ranks (χ^2=19.43, $(\chi^2)_{d.f.=4,\alpha=.05}$=9.49). The proportion of officers reporting they possess "Excellent" managerial skills increases as officers progress through the ranks (Figure 20).

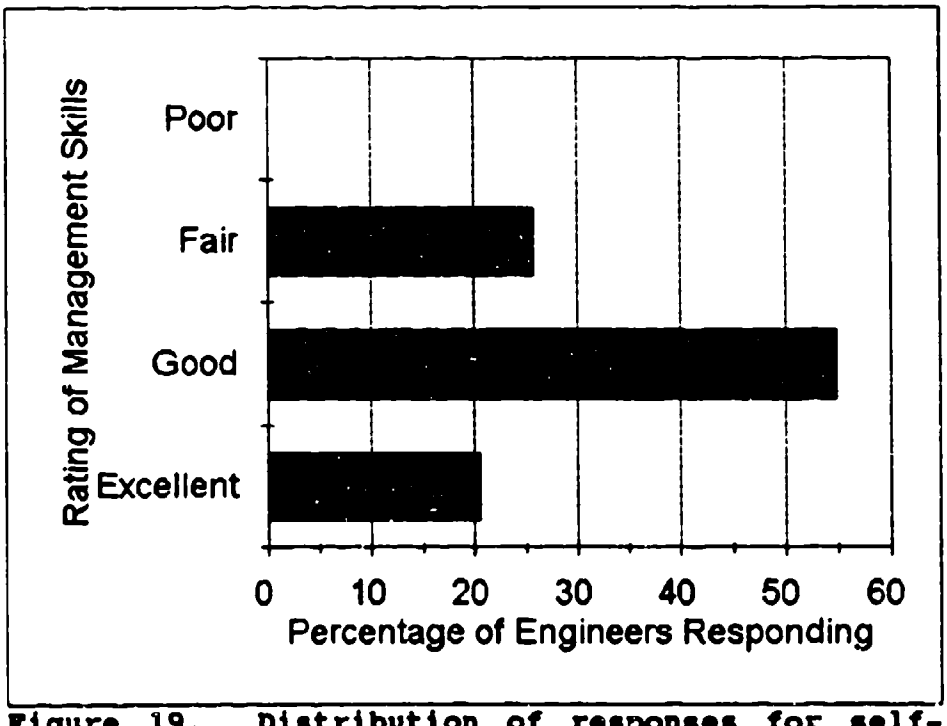

Figure 19. Distribution of responses for self-assessment of managerial skills.

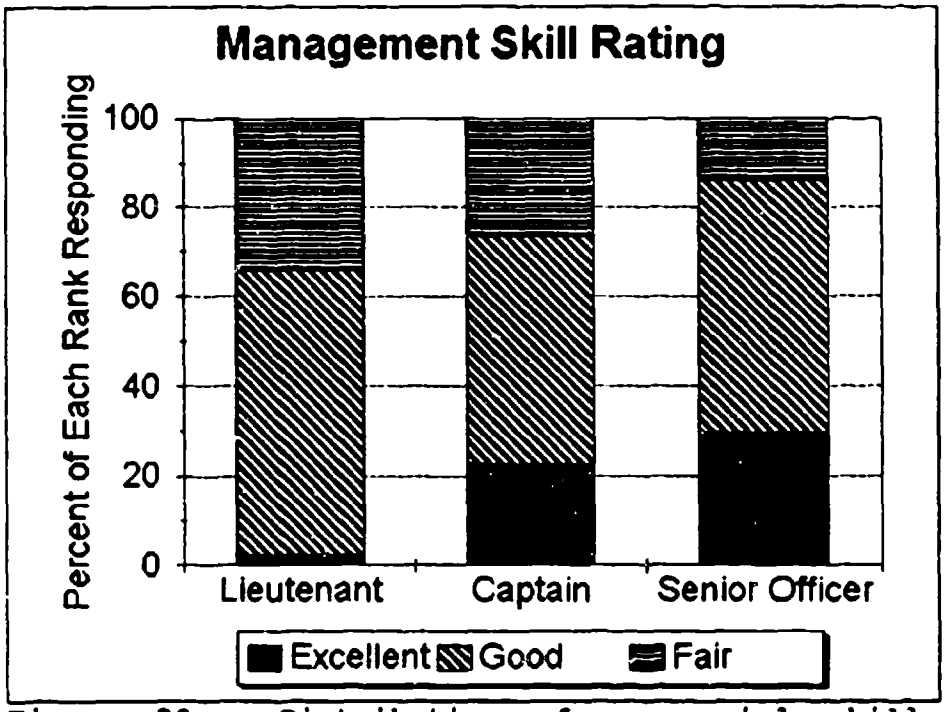

Figure 20. Distribution of managerial skills rating by rank.

Additionally, this study examined engineering officers competence with specific management activities such as organizing and directing teams.

Organizing Teams. As part of their managerial duties, the engineers surveyed may occasionally be required to organize a team. More than 72% of the engineers responded affirmatively that they are good at organizing teams. Less than 10% responded negatively with regards to their abilities to organize teams (Figure 21).

Directing Teams. Another function engineers may be called upon to perform is to lead or direct teams. Even

more of the engineers (76%) agreed that they were good at directing teams than indicated proficiency at organizing teams. Slightly more than 12% of engineers indicated they disagreed at some level to the statement that they were good at directing teams (Figure 21).

Communication Skills. Communications skills are critical to success in nearly every job. When engineers were asked if they had the communication skills to succeed in their jobs, including the managerial functions, over 87% of them agreed that they did. Only 7% did not agree they had the communication skills required to be successful (Figure 21).

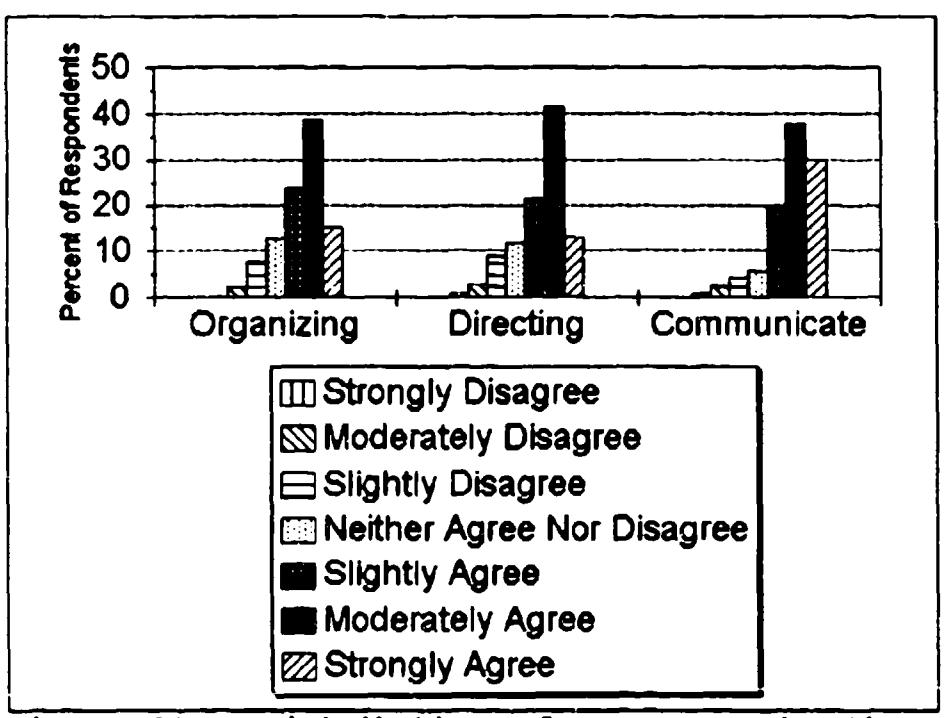

Figure 21. Distribution of responses to three management functions.

Investigative Question 2C. Does the perceived adequacy of training in preparation for managerial responsibilities vary as a function of personal characteristics? This study explored whether personal characteristics such as the commissioning source, the number of years of acquisition experience, and the type of graduate education received influenced the perceived adequacy of the preparation for management.

Commissioning Source. Each of the Air Force officer commissioning programs devotes portions of the curriculum to leadership development. However, the degree to which leadership or management is emphasized may vary between the commissioning programs. This study examined the extent to which the potential differences in commissioning programs may have influenced the perceived adequacy of management preparation. This study determined that there was not a significant difference in the extent to which officers who graduated from each of the commissioning programs viewed the adequacy of their preparation to perform managerial functions (χ^2=8.60, $(\chi^2)_{d.f.=4,\alpha=.05}$=12.59).

Job Tenure. The amount of time spent in acquisition engineering may contribute to perceptions of proficiency. Each engineering officer in an acquisition

position over a period of time, works in several jobs varying in scope and breadth of responsibility as well as location and type of organization. Most officers will receive opportunities for additional training and education which vary in kind and number. These and other factors that may vary over time between different officers may have influenced the perceived adequacy of management preparation. This study determined that there was not a significant difference in the extent to which officers who have different amounts of acquisition experience viewed the adequacy of their preparation to perform managerial functions (χ^2=9.62, $(\chi^2)_{d.f.=4,\alpha=.05}$=12.59).

Graduate Education. Acquisition engineering officers will have acquired different kinds and levels of graduate education since commissioning. There is, of course, a considerable difference of emphasis on management between various graduate degree programs. This study examined the extent to which the potential differences in graduate education programs may have influenced the perceived adequacy of management preparation. This study determined that there was a significant difference in the extent to which officers who have participated in various graduate education programs viewed the adequacy of their preparation to perform managerial functions (χ^2=14.20, $(\chi^2)_{d.f.=4,\alpha=.05}$=12.59). Engineers with a management graduate

degree or working on a management degree are nearly twice as likely to rate their management training as "Excellent" as those with technical graduate degree and are more than three times as likely to rate their training "Excellent" as engineers that have no graduate degree at all and are not working on one (Figure 22). The observations support a conclusion that engineers with more management credit hours rate their management skills more highly.

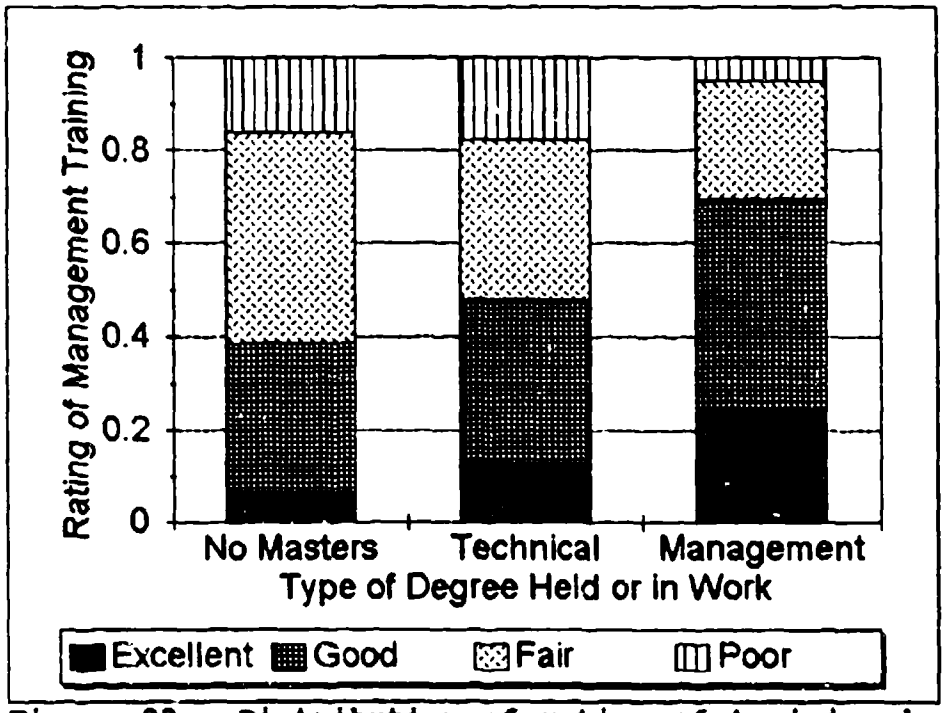

Figure 22. Distribution of rating of training by degree type.

Research Question III. To what extent are various training efforts contributing to engineering officer's abilities to perform management functions?

Investigative Question 3A. From the provided list of items, which contribute most to managerial competency? In the course of performing their jobs, Air Force acquisition engineers are exposed to and provided numerous kinds of training both formal and informal. This study investigates which of several items that are possible contributors to managerial competency are perceived by engineers to be the most effective. The list of nine potential contributors which engineers rated for effectiveness are shown in descending order in Table 5. The Friedman Statistic corrected for ties was 238.3 with a P-value for the Chi-squared approximation of 0.0000 at eight degrees of freedom. This result indicates there is essentially no possibility that all of the items in the ordered list were rated equally effective. The key observation from a review of Table 5 is that the number one rated contributor to managerial competence is managerial experience. Following experience, several groupings of contributing factors were found. Innate talent is indistinguishable from having a mentor and other acquisition experience as the number two

most highly rated contributor to managerial competency. The third group is composed of masters degree, SOS, and Systems 200. The group SOS, Systems 200, and Systems 100 form the forth ranked group and overlaps the third ranked set of contributors. The final group consists of other PME, Systems 100, and Systems 200 and overlaps both the fourth and third ranked groups of contributors. The items that are statistically indistinguishable from each other are identified in the table by bar markings in adjacent rows with a columns for each group. A noteworthy observation is the four most highly rated contributors with the exception of innate talent are all experience factors. All of the education and training factors rank five through nine in the list and form groups of contributors three through five.

TABLE 5

CONTRIBUTORS TO MANAGERIAL COMPETENCY

Rank Order of Possible Contributors to Competency				
Managerial Experience				
Innate Talent	■			
SPO, Lab, or ALC Experience	■			
Mentor	■			
Masters Degree		■		
SOS		■	■	
Systems 200		■	■	■
Systems 100			■	■
Other PME				■

Investigative Question 3B. Are APDP requirements important contributors to managerial competence relative to other factors? Three of the primary APDP requirements are acquisition experience, Systems 100 and Systems 200. All three are in the list of potential contributors to managerial competency. Their positions in Table 5 along with the bar markings indicates their significance relative to the other contributors. SPO, Lab, or ALC experience is near the top of the list in position number three and in the group of factors rated second. Experience in acquisition position is obviously an important contributor to managerial competency. The ratings for the other two APDP items, Systems 100 and Systems 200, place them near the bottom of the ranks of potential contributors to managerial competency. They are not perceived to contribute as significantly to managerial competency as do the other factors.

Summary

This chapter contained the results of the tests performed in an effort to answer the research questions of this study. Significant findings were identified with the research results.

V. Discussion and Conclusions

Introduction

The need of the Air Force for acquisition managers within all acquisition specialties including engineering is critical. Management training is one portion of the career development an acquisition engineer must undertake to ensure a successful career in the Air Force. Do Air Force engineers see their positions as engineering specialists only. Do engineers they recognize the large management content of their daily activities? Is the management training and education received by engineers perceived as adequate to meet the requirements of their jobs, and which training has been most beneficial? This chapter discusses the results of examining these questions and the implications of the research findings.

The findings of this research relative to the objectives in chapter one will be reviewed. The limitations of this study will be discussed and possibilities for additional studies will be presented.

Overview

Industrial firms and research organizations throughout the world are in a position of managing increasingly complex efforts. As a result, the need for technical managers or managers of technology has also increased. The

logical place to obtain these needed technical managers is from among the engineers working at developing and using the new technologies. That process however, has not been as successful as desired. The Air Force directly produces very few products, but is heavily involved in research and development and in the oversight of the production and delivery of some of the most complex and technically advanced systems in the world. Because of its personnel policies, the Air Force tends to transition its engineering officers to management positions even earlier than its counterparts (Department of the Air Force, 1990; Hood, 1990).

Conclusions

The objectives of this research were to determine if engineering officers are spending a substantial portion of their time managing, if those officers believe their management training has been adequate to prepare them for the amount of managing they do, and to determine which management training efforts have been most effective. A survey was chosen as the method to acquire data to accomplish these objectives. The acquisition engineering officers assigned to Wright-Patterson AFB were selected as the sample along with their supervisors. Survey responses were analyzed with descriptive statistics and nonparametric tests.

Objective One. The first objective of this research was to determine if acquisition engineering officers are spending a substantial portion of their time performing management functions. For the purposes of this study, a substantial portion was defined as 25% or more of an average workday. Sixty-eight percent of the responding engineers reported spending at least 25% of their time managing, and this was supported by 68.0% of their supervisors. A large percentage, nearly 52%, of the engineers reported spending more than 50% of an average workday managing.

This study indicates that time spent in performing management functions increases with increasing rank. Fifty-five percent of the Lieutenants responding to the survey are spending as much as 25% of their time managing and 54% of Captains spend more than one-half of their time managing. Senior officers reported 75% of their time was spent managing. These results were supported by responses to questions about the frequency of participation in specific management functions which included, directing others, budgeting, and planning activities. Engineers reported on average directing others and participating in planning activities 2-3 times per week. Budgeting activities were engaged in only once per month or less. The analysis of collected data supports the conclusion that

acquisition engineers in large numbers are spending a great deal of their time performing management functions.

DoD 5000.52M states, "part of the acquisition work force must be systematically developed through a progressive career program that prepares selected individuals to become senior managers within acquisition" (1990: 1-3). The results of this investigation indicate that acquisition engineering officers are heavily involved in this process already. If the Air Force is to avoid the problems typical of industries' sink-or-swim management progression process, the part of the DoD 5000.52M statement that says, "Systematically developed through a progressive career program," needs to be more than just giving engineering officers progressively more management functions to perform as they rise in rank.

Objective Two. The second objective of this research was to determine if engineering officers perceived the training and education they had received as adequate in preparing them to meet the managerial responsibilities of their jobs. A substantial portion of engineers, 53.2%, felt their management training had been either "Excellent" or "Good." There was no difference between the military ranks in response to this question.

Not even a single acquisition engineer rated his or her management skills as "Poor." Management skills were

rated either "Good" or "Excellent" by 72% of the respondents. This finding is not what one would expect from reviewing the literature in this area. The implication is that Air Force acquisition engineering officers are in some way different from the population of engineers and engineering managers as a whole. Whether due to some characteristic of Air Force engineers or to the Air Force career progression process or both, (remember not even one the new Second Lieutenants rated his or her management skills as poor), the Air Force appears, from these results, to have avoided industry's problem with making managers of engineers. When rating their skills and abilities to perform management functions, the engineers were actually slightly more conservative than their supervisors in their assessments. In the key area of communication skills, 87% of the responding engineers agreed that they had the communication skills to be successful in their jobs.

This study indicates that the type of graduate degree held or in work influences responses to the question about managerial skills. Engineers that have or are working on a management type of graduate degree are nearly twice as likely to rate their managerial skills as "Excellent" than engineers that have or are working on technical graduate degrees. Assuming that the most skilled worker is also more effective and efficient, this finding leads to the

conclusion that the Air Force should be encouraging and selecting more engineering officers to attend graduate management programs.

Objective Three. The third and final objective of this research was to determine which training efforts are the most effective contributors to managerial competency for engineering officers. A list of possible contributors to managerial competency was provided to engineers to be rank ordered for the perceived level of contribution to a personal ability to manage. Managerial experience placed highest followed by personal talent or aptitude for management. Acquisition experience was third in order. Working under a mentor was placed fourth, ahead of a masters degree. The items rated lowest for contribution to managerial competency were PME, and Systems 100 and Systems 200.

When looking specifically at APDP requirements that might contribute to improved management abilities, this study found that acquisition experience is rated very highly. Systems 100 and Systems 200 are rated as contributing less. Experience may be an APDP requirement, but it is something most engineers would get anyway. If the purpose of APDP is to add something to the process, an obvious answer is to change the content of Systems 100/200 such that they are perceived as more beneficial.

These are highly interesting results. Readings from the literature indicate that industry finds experience to be an inefficient method of preparing engineers for management. Additionally, previous results from this study indicated that engineers with graduate management credit hours rate their managerial skills higher than their peers with graduate technical credit hours. One possible explanation is that Air Force acquisition engineers have found additional management training and education most beneficial when combined with opportunities to put it into practice.

Recommendations

Several recommendations can be made based on the results of this study.

1.) One of the items that placed relatively high in the list of contributors to managerial competency was having a mentor. There is not currently a formal mentor program for acquisition engineers. Apparently a number of engineering officers have established their own informal program. It may be worthwhile for the Air Force to establish a mentor program for acquisition engineers.

2.) A recommendation for improving APDP's contribution to managerial competence, one of the stated goals of the APDP program, would be to change

the content of Systems 100 and Systems 200 to boost perceived value of these courses as contributors to managerial competency. Since these courses are cornerstones of the APDP process, the course content should probably be modified to enhance their contribution.

3.) On-the-job experience is apparently an important factor in the management skills ratings of senior officers. This is typically an inefficient way to learn. More than 40% of lieutenants report spending more than 25% of their time performing management functions so it may be beneficial to provide them at least some amount of additional formal management training early in their careers.

4.) More than 43% of engineers reported participating in budgeting activities less than quarterly or not at all. Since the goal appears to be to prepare the acquisition work force for eventual positions as acquisition managers, a method should be established to get engineers involved in the budgeting process if they are to be given a "well rounded" preparation for management positions.

Research Limitations and Recommendations for Future Studies

Several significant findings resulted from this research, chief among them is that a large portion of the

job content of acquisition engineering consists of management functions. However, contrary to findings in the literature, the engineers and their supervisors appear to be satisfied with their management skills. The engineers also indicated on the whole that their management related training was adequate to meet the needs of their jobs. Based on previous studies, the large size of the sample, and high response rate, the results of this study should be representative of the entire study population. The chosen sample is not a random sample of the study population however. It was chosen for convenience and ease of administration with consideration given to previous research that indicated such a sample was reasonably representative of the population. Generalizations to the population should be done with care.

Several suggestions for future research can however be recommended.

1.) The Air Force has changed considerably in the last two or three years both in size and organization. Subsequent studies might include other product divisions to verify that the assumption WPAFB personnel are representative of all Air Force acquisition personnel is still valid.

2.) Some of the findings of this study are contrary to those of the literature reviewed. This may be due to basic traits of those who elect to become military

officers or to their military training. Subsequent studies should include civil service engineers and if possible engineers employed by civilian companies. Additional studies might also investigate the specific contributions of military training.

3.) The list of factors contributing to managerial competency should be expanded to be more comprehensive and specific. For example, additional requirements for APDP certification could be included, the specific courses required for various levels of certification in management and technical areas should each be listed.

4.) This study was able to show that the engineers responding to the survey were not inflating the self-assessments of their managerial skills or the time they spend managing. The study was not able to verify that the engineer and supervisor responses are correlated. Additional studies should take further efforts to establish such a correlation.

5.) Engineers and their supervisors were asked for their perceptions about several aspects of the engineers' management skills. Some of the engineers are also supervisors. A method should be found to obtain subordinate's perceptions of management skills. Perceptions could also be obtained from peers and members of teams associated with the engineers.

Appendix A: Engineer Survey

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AERONAUTICAL SYSTEMS CENTER (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE OHIO

19 OCT ...

FROM: ASC/ENO (Lt Col Carpenter, DSN 785-7126)

SUBJ: Survey on Air Force Engineers (28xx) Training

TO: Survey Respondents

1. As the Air Force continues to downsize it is important that all personnel are utilized most efficiently. One key to efficient employees is to ensure each one is qualified to perform all aspects of his or her job. This survey is sanctioned by AFMPC, (survey control number USAF SCN 93-91), and has two parts. The first part is designed to determine to what degree our 28xx personnel are performing management functions and how they feel about that part of their jobs. The second part is for supervisors of 28xx personnel and seeks to determine how well they feel their engineers have been prepared to accomplish management activities.

2. This is not a test and there are no right or wrong answers. If this study is to be helpful, it is important that you respond to each statement as thoughtfully and frankly as possible. Please take the time to fill out the survey completely and answer the questions independently and without consulting with your supervisor. The survey is designed to collect the required information with the fewest possible questions and to minimize the time required from your busy schedule.

3. Your name was selected from 28xx personnel who work within ASC/EN at Wright-Patterson AFB. The survey measures your perceptions and attitudes toward certain aspects of your job. The data gathered will become part of an AFIT research project and may influence training requirements if we find significant problems. Your individual responses will be combined with others and will not be attributed to you personally. To ensure complete confidentiality, please do not write your name anywhere on the returned answer sheet.

4. Your participation is voluntary, but we would appreciate your help. For further information, contact Capt Steven Woodruff, at 255-3464.

GEORGE CARPENTER, Lt Col, USAF
Coordinating Manager for
Military Acquisition Resources
Engineering Operations Division

3 Atchs
1. Survey
2. Answer sheet
3. Return envelope

Survey Instructions

1. All items are answered by filling in the appropriate spaces on the machine-scored response sheet provided. If for any item you do not find a response that fits your opinion exactly, use the one that is closest to the way you feel. Some questions do have a N/A (not applicable) response as on of the choices. Please observe the following:

   a. Do not write your name anywhere on the response form.

   b. Do not fold, bend, staple or mutilate the response form.

   c. Mark only one answer when responding to each question.

   d. Erase completely any response you wish to change.

   e. Do use a Number 2 pencil.

   f. Completely fill in the appropriate space for each answer.

2. Demographic questions are for assisting in data analysis only and will in no way be used to identify respondants.

3. Any additional comments can be written on the backs of survey question sheets and returned with the machine-scored response sheet.

4. After completing the survey, please put the response sheet and any comment sheets in the self-addressed envelope provided, seal and put into base distribution. Please complete the survey by 15 Nov. 1993.

5. Estimated completion time for this survey is 7-10 minutes.

Thank You For Your Participation

DEMOGRAPHIC QUESTIONS

1. What is your rank?

1. __ 2 Lt
2. __ 1 Lt
3. __ Capt
4. __ Maj
5. __ Lt Col
6. __ Col
7. __ Other

2. What is your AFSC?

1. __ 2816
2. __ 2825
3. __ 2835
4. __ 2845
5. __ 2855
6. __ 2865
7. __ 2875
8. __ 2895
9. __ Other

3. What is your gender?
1. __ Male
2. __ Female

4. What is the highest level of Professional Military Education (PME) you have completed?

1. SOS
2. ISS
3. SSS
4. Other
5. None

5. What was the source of your commission?

1. ROTC
2. OTS
3. USAFA
4. Other

6. Indicate the number of years you have worked in acquisition positions; either at product centers, Air Logistics Centers, laboratories, or a combination.

1. Less than 3 years,
2. 3 years but less than 8 years,
3. 8 years or more.

7. In what speciality is your undergraduate degree.

1. Electrical Engineering
2. Aeronautical Engineering
3. Mechanical Engineering
4. Civil Engineering
5. Industrial Engineering
6. Chemical Engineering
7. Astronautical Engineering
8. Other (specify) _____

8. In what discipline is your graduate degree or the one you are pursuing?

1. I neither have a master's degree nor am I pursuing one at this time.
2. Engineering/Technical/Science
3. Management (Business, Production Operations Methods, etc)
4. Other

9. What is the highest Acquisition Program Development Plan (APDP) certification level you have applied for in Program Management?

1. I have not applied.
2. Level 1
3. Level 2
4. Level 3

10. What is the highest APDP certification level you have applied for in a technical area (engineering, T&E, QA, etc.)

1. I have not applied.
2. Level 1
3. Level 2
4. Level 3

11. Select the response indicating the number of credit hours (both undergraduate and graduate) you have in subjects contributing to your technical competency:

1. Less than 25 credit hours,
2. 25 but less than 50 credit hours,
3. 50 but less than 90 credit hours,
4. 90 but less than 120 credit hours,
5. 120 or more credit hours.

12. Select the response indicating the number of credit hours (both undergraduate and graduate) you have in subjects contributing to your managerial competency:

1. Less than 5 credit hours,
2. 5 but less than 10 credit hours,
3. 10 but less than 40 credit hours,
4. 40 but less than 70 credit hours,
5. 70 or more credit hours.

TO WHAT EXTENT DO OUR ENGINEERS (28XX) MANAGE

13. Indicate the percent of time you spend during an average workday performing management functions. The traditional management functions include planning, controlling, directing, scheduling, budgeting, and staffing.

1. Less than 10%,
2. 10% but less than 25%,
3. 25% but less than 50%,
4. 50% but less than 75%,
5. More than 75%.

14. How frequently do you direct the activities of others?

1. Daily
2. 2-3 times per week
3. Weekly
4. Monthly
5. Quarterly
6. Less than quarterly or not at all

15. How frequently do you engage in budgeting activities?

1. Daily
2. 2-3 times per week
3. Weekly
4. Monthly
5. Quarterly
6. Less than quarterly or not at all

16. How frequently do you engage in planning activities?

1. Daily
2. 2-3 times per week
3. Weekly
4. Monthly
5. Quarterly
6. Less than quarterly or not at all

ARE ENGINEERS ADEQUATELY TRAINED/EDUCATED FOR THE MANAGEMENT RESPONSIBILITIES WHICH THEY MUST FULFILL?

17. How would you rate your training and education in preparing you for the managerial responsibilities of your current job?

1. Excellent
2. Good
3. Fair
4. Poor

18. How would you rate your managerial skills?

1. Excellent
2. Good
3. Fair
4. Poor

The following questions are designed to measure your feelings about your ability to perform managerial functions. Use the scale shown below to rate your answers to questions 19-24.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree nor Disagree	Slightly Agree	Moderatey Agree	Strongly Agree
1	2	3	4	5	6	7

19. I meet my own personal expectations for managerial expertise in this job.

20. I make the best contribution in areas unrelated to the managerial aspects of this job.

21. I honestly believe I have all the managerial skills needed to succeed in this job.

22. I am good at organizing teams.

23. I am good at directing teams.

24. I have the communication skills, (listening, negotiating, briefing, persuading, etc.) to be successful in this job.

WHAT ARE THE MOST EFFECTIVE CONTRIBUTERS TO THE DEVELOPMENT OF MANAGERIAL COMPETENCY IN ENGINEERS?

To what do you attribute your ability to manage effectively? Please rank order from 1 to 9 the following items to indicate their contribution to your managerial abilities using 1 the for largest contributer. Leave blank any item that does not apply to you.

25.__ Managerial Experience
26.__ Innate Talent
27.__ Masters Degree
28.__ SOS
29.__ Other PME
30.__ Mentor
31.__ Systems 100
32.__ Systems 200
33.__ SPO, LAB or ALC Experience

How much have the following items contributed to the development of your managerial competency? Use the scale below to rate the contributers in questions 34-43 below. If a question is not applicable to your situation or experience, (you have not had Systems 200 for example), the appropriate response is number 6 not applicable (N/A).

Extremely Useful	Of Considerable Use	Of Use	Not Very Useful	Of No Use	N/A
1	2	3	4	5	6

34. Professional readings (e.g., journals, periodicals, manuals, etc.)

35. Training courses that satisfy APDP training requirements for either Program Management or technical certification.

36. Having a mentor or working under an authority or expert in the organization you work in.

37. Operational experience.

38. Experience in an acquisition management position, (OJT).

39. Accredited undergraduate or graduate management degree program.

40. Your personal aptitude for management skills and functions.

41. Professional Military Education (SOS, ISS, etc.)

42. Systems 100.

43. Systems 200.

Appendix B: Supervisor Survey

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AERONAUTICAL SYSTEMS CENTER (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE OHIO

FROM: ASC/ENO (Lt Col Carpenter, DSN 785-7126)

SUBJ: Survey on Air Force Engineers (28xx) Training

TO: Supervisory Survey Respondents

1. As the Air Force continues to downsize it is important that all personnel are utilized most efficiently. One key to efficient employees is to ensure each one is qualified to perform all aspects of his or her job. This survey has been sanctioned by AFMPC, (survey control number USAF SCN 93-91), and has two parts. The first part is designed to determine to what degree our 28xx personnel are performing management functions and how they feel about that part of their jobs. The second part is for supervisors of 28xx personnel and seeks to determine how well they feel their engineers have been prepared for accomplishing management activities.

2. This is not a test and there are no right or wrong answers. If this study is to be helpful, it is important that you respond to each statement as thoughtfully and frankly as possible. Please take the time to fill out the survey completely and answer the questions independently and without consulting with your employee. The survey is designed to collect the required information with the fewest possible questions and to minimize the time required from your busy schedule.

3. Your employee's name was selected from 28xx personnel who work within ASC/EN at Wright-Patterson AFB. This survey measures your perceptions and attitudes about his or her performance in certain aspects of his or her job. The data gathered will become part of an AFIT research project and may influence training requirements if we find significant problems. Your individual responses will be combined with others and will not be attributed to you personally. To ensure complete confidentiality, please do not write your name anywhere on the returned answer sheet.

4. Your participation is voluntary, but we would appreciate your help. For further information, contact Capt Steven Woodruff, at 255-3464.

GEORGE CARPENTER, Lt Col, USAF
Coordinating Manager for
Military Acquisition Resources
Engineering Operations Division

3 Atchs
1. Survey
2. Answer sheet
3. Return envelope

Survey Instructions

1. All items are answered by filling in the appropriate spaces on the machine-scored response sheet provided. If for any item you do not find a response that fits your opinion exactly, use the one that is closest to the way you feel. Some questions do have a N/A (not applicable) response as on of the choices. Please observe the following:

    a. Do not write your name anywhere on the response form.

    b. Do not fold, bend, staple or mutilate the response form.

    c. Mark only one answer when responding to each question.

    d. Erase completely any response you wish to change.

    e. Do use a Number 2 pencil.

    f. Completely fill in the appropriate space for each answer.

2. Demographic questions are for assisting in data analysis only and will in no way be used to identify respondents.

3. Any additional comments can be written on the backs of survey question sheets and returned with the machine-scored response sheet.

4. After completing the survey, please put the response sheet and any comment sheets in the self-addressed envelope provided, seal and put into base distribution. Please complete the survey by 15 Nov. 1993.

5. Estimated completion time for this survey is 3-4 minutes.

Thank You For Your Participation

The following questions are designed to measure your feelings about your subordinate's ability to perform managerial functions. Use the scale below to rate your answers to questions 1-7.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree nor Disagree	Slightly Agree	Moderatey Agree	Strongly Agree
1	2	3	4	5	6	7

1. He/she spends a substantial portion, (more than 25%), of his/her time during an average workday performing management functions. The traditional management functions include planning, controlling, directing, scheduling, budgeting and staffing.

2. He/she meets my expectations for managerial expertise in this job.

3. He/she makes the best contribution in areas unrelated to the managerial aspects of this job.

4. He/she has all the managerial skills needed to succeed in his/her current job.

5. He/she does a good job organizing teams.

6. He/she does a good job directing teams.

7. He/she has the communication skills, (listening, negotiating, briefing, instructing, persuading, etc.) to be successful in this job.

Appendix C: Engineer Responses

	Qstn #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	I.D. #																						
1	64	3	2	1	1	1	1	1	3	1	2	3	3	3	4	6	3	2	2	5	4	3	5
2	191	3	5	1	1	2	3	2	3	1	2	5	3	5	2	6	2	3	2	6	4	7	6
3	151	3	8	1	1	1	2	2	2	1	2	5	3	1	6	6	6	3	3	6	7	3	2
4	66	4	2	1	1	3	3	1	3	3	4	3	4	3	2	6	4	2	2	5	4	7	6
5	45	4	2	1	1	2	3	1	2	1	4	5	4	4	1	2	1	2	2	5	6	1	5
6	261	3	2	1	1	2	2	1	2	2	2	5	2	4	3	6	3	4	3	2	7	2	3
7	39	3	2	1	1	3	1	1	2	1	3	4	3	3	4	4	1	3	2	5		3	6
8	136	3	5	1	1	2	2	2	3	2	3	3	4	1	6	6	1	3	2	6	4	3	6
9	112	3	5	1	1	1	2	2	1	2	2	3	4	5	1	5	1	2	1	6	6	5	7
10	149	3	2	1	1	2	2	1	2	3	2	5	3	5	3	6	6	2	2	5	4	4	3
11	28	1	9	1	5	1	1	1	1	1	2	3	2	1	4	6	2	3	3	5	6	4	3
12	244	5	6	1	3	3	2	7	2	3	4	5	5	3	1	1	1	1	1	7	4	6	7
13	80	3	9	1	1	1	1	8	2	1	2	4	3	1	6	6	6	3	2	6	7	4	3
14	260	5	1	1	2	3	3	1	2	1	4	4	3	5	1	4	1	1	2	5	5	5	6
15	281	3	2	1	1	2	2	1	2	3	2	5	3	5	1	4	1	3	2	5	4	6	6
16	247	3	2	1	1	2	2	1	2	1	3	5	3	3	5	6	4	3	3	3	3	3	4
17	9	1	2	1	5	1	1	1	1	1	2	4	3	2	4	6	1	2	2	5	4	5	5
18	114	3	3	1	1	2	3	3	3	3	4	2	5	4	1	1	1	1	1	6	3	7	6
19	82	1	9	1	5	1	1	1	4	1	1	5		1	6	6	6	2	2	4	2	2	6
20	44	3	2	1	5	1	2	1	2	1	3	5	3	1	3	5	3	4	3	6	6	3	4
21	103	3	2	1	1	2	3	1	3	2	4	3	3	3	2	6	4	2	2	5	3	5	4
22	43	5	1	1	2	1	3	3	2	1	4	3	3	5	1	3	1	2	2	6	2	5	5
23	97	2	2	1	4	2	2	1	1	1	2	2	1	3	2	5	3	4	3	4	3	2	3
24	286	1	2	1	5	3	1	1	3	2	2	2	3	3	5	3	4	3	2	6	4	6	6
25	252	3	5	1	5	3	1	7	2	2	2	5	3	2	3	6	4	4	2	6	2	2	7
26	6	2	5	1	5	1	1	2	1	1	2	3	3	3	6	1	4	4	2	2	5	2	3
27	11	3	5	1	1	2	3	2	3	3	4	5	5	5	1	6	6	1	1	6	2	6	5
28	235	4	3	1	1	2	3	3	2	3	4	5	3	5	1	6	3	4	3	3	2	4	5
29	174	3	3	1	1	1	2	3	2	1	3	4	3	2	3	5	3	4	3	5	5	4	5
30	249	1	9	1	5	1	1	1	1	1	1	4	2	2	6	6	4	2	3	6	4	6	5
31	46	3	5	1	5	1	2	2	2	2	2	4	2	3	2	5	1	2	2	6	7	5	4
32	51	3	2	2	1	1	2	1	3	2	3	5	4	5	2	2	1	2	2	6	2	3	6
33	27	3	2	1	1	1	2	1	2	1	2	5	3	2	4	6	4	3	3	3	7	5	5
34	227	3	2	1	4	3	3	1	2	2	2	5	1	2	3	5	3	3	2	5	6	3	2
35	171	1	9	1	5	1	1	8	2	1	1	4	2	1	6	6	4	2	2	3	2	3	4
36	101	3	2	1	5	1	2	1	2	3	3	5	3	3	2	4	1	3	2	6	4	3	6
37	242	3	3	1	1	1	3	3	2	1	2	5	3	5	1	3	3	3	1	6	4	7	6
38	129	4	9	1	2	2	3	2	2	3	3	5	3	5	1	3	1	2	2	6	1	6	6
39	194	3	3	1	1	1	3	3	3	3	4	5	4	5	1	4	1	2	2	6	6	5	5
40	147	2	5	1	5	1	1	2	2	1	2	5	2	3	4	6	2	1	3	6	7	3	4
41	49	1	3	2	5	1	1	3	1	1	1	5	2	1	3	6	3	3	3	3	2	2	5
42	238	3	5	1	1	1	3	2	2	1	2	5	1	1	6	6	6	4	3	6	4	7	4
43	115	3	5	1	1	2	2	2	3	2	2	4	3	4	4	4	4	2	2	6	6	6	6
44	58	4	9	1	2	2	3	3	2	3	4	5	3	2	1	5	4	1	2	6	6	6	4
45	10	3	2	1	5	1	2	1	3	2	3	6	3	3	3	4	1	3	3	3	3	1	6
46	138	3	3	1	5	1	1	3	2	1	2	5	3	1	6	6	4	4	3	5	7	3	3
47	212	1		1	5	1	1	3	1	1	1	5	3	3	6	6	3	3	2	6	5	7	6
48	59	4	9	1	2	3	2	2	2	2	3	4	4	3	1	4	2	2	1	6	6	3	6
49	32	3	4	1	1	2	2	7	2	3	3	5	3	1	6	6	4	1	1	1	7	7	6
50	77	5	9	1	2	1	2	7	2	1	3	5	3	5	1	6	3	3	2	4	4	5	5
51	132	3	3	1	1	2	3	3	2	2	2	5	4	3	1	3	3	1	2	7	5	6	6
52	14	3	2	1	1	1	1	1	2	2	2	4	2	2	6	6	4	4	2	5	6	6	6
53	5	3	2	1	1	2	3	1	1	1	3	1	2	4	1	3	1	3	2	4	6	6	6

Appendix C: Engineer Responses

	Qstn # I.D. #	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1	64	5	6	1	5	4	6	7	2	8		3	3	4	2	3	2	3	3	4	4	6
2	191	6	6	2	1	5	6		3	8	7	4	4	4	1	6	1	3	1	3	4	3
3	151	2	3	1	3	4	5	6		8	7	2	2	3	6	6	1	2	1	3	3	3
4	66	6	7	2	1	8	5	9	3	7	6	4	4	3	1	5	2	3	2	3	3	3
5	45	4	5	3	9	4	5	8	2	7	6	1	3	3	1	2	2	6	2	3	3	3
6	261	3	2	2	7	6	4		3	5		1	3	2	1	6	1	6	2	2	2	6
7	39	6	6	1	2	5	7	9	3	8	6	4	3	3	1	1	1	3	2	4	3	2
8	136	6	7	1	4	2	3	6		8	8	5	3	1	6	6	1	1	3	3		
9	112	7	6	2	3					5	4	1	3	2	1	2	1	4	2	4	4	2
10	149	3	4	6	1	5	4	9	3	8	7	2	4	3	1	6	1	3	2	3	4	4
11	28	3	5	4	3				1	2		5	3	2	3	2	2	6	2	6	3	6
12	244	7	7	1	3	7	8	6	9	5	4	2	2	2	3	2	1	2	2	3	3	3
13	80	3	4	6	7	3	1		5	4		2	3	3	4	2	2	3	4	2	3	6
14	260	5	5	1	7	9	2	8	3	6	5	4	2	2	2	2	1	6	2	2	2	2
15	281	6	7	1	3	8	4	5	9	7	6	2	4	2	3	6	1	6	1	2	2	2
16	247	4	4	1	2	9	3	8	5	6	7	4	3	3	2	6	2	6	3	3	3	3
17	9	5	5		2					3		1	3	3	1	6	2	6	2	6	5	6
18	114	6	6	2	4	5	6	9	1	7	8	3	4	3	1	3	2	3	3	2	4	4
19	82	6	7	2	1	3							2	6	6	6	6	6	1	6	6	6
20	44	4	6	2	1	5			4	3		6	3	3	2	6	6	2	3	6	3	6
21	103	5	7	2	8	4	5		1	7	6	3	4	3	1	1	1	3	3	3	3	3
22	43	6	6	1	2	9	6	8	4	7	5	3	2	3	1	1	1	6	1	3	4	2
23	97	3	4	4	2					3		1	4	4	2	1	6	6	3	6	3	6
24	286	6	7	6	4	7	9	3	5	2	8	1	4	2	2	2	2	3	2		2	6
25	252	7	7		1	5				4	3	2	2	2	4	2	6	6	1	6	5	3
26	6	3	4	4	3					2		1	3	3	6	6	3	6	2	6	3	6
27	11	6	6	2	5	1	8		4	7	6	3	1	3	2	6	2	1	1	3	3	3
28	235	5	6	1	3	5	8	9	4	7	6	2	3	4	6	3	2	4	2	4	4	3
29	174	5	5	1	6	8	5	9	2	7	4	3	4	1	2	3	2	2	3	4	3	
30	249	5	5		1					2		3	4	3	2	6	6	3	2	6	3	6
31	46	5	5	2	1	4	5	6	7	8	9	3	3	3	2	2	2	2	1	3	2	3
32	51	7	5	3	9	4	1	8	5	7	2	6	2	1	1	1	3	3	3	1	3	1
33	27	5	2	3	5	4	6	9	1	8	7	2	3	5	1	6	1	6	3	3	5	5
34	227	2	2	1	2	9	6	7	3	8	5	4	4	3	2	1	1	3	2	3	3	3
35	171	4	7	2	3				4	5		1	3	4	2	6	6	6	2	6	4	6
36	101	5	6		3				2	5	4	1	4	3	1		1	2	2		3	3
37	242	6	7	1	3	2	9	7	4	6	5	2										
38	129	6	6	1	2	4	8	5	3	7	6	3	3	3	3	2	1	6	1	3	4	4
39	194	5	5	2	7	3	8	9	4	5	6	1	4	3	1	3	2	3	2	3	3	3
40	147	4	6	4	1	6	8	9	3	5	7	2	6	4	1	6	2	6	2	6	3	6
41	49	4	7		2				1	3		4	6	3	1	6	6	6	2	6	3	6
42	238	4	3	1	4	7	8		2	9		3	6	5	6	6	6	6	3	5	5	6
43	115	6	6	2	4	9	6	3	8	7	6	1	3	3	1	1	2	2	2	3	3	
44	58	5	6	3	1	8	5	4		7	6	2	4	3	3	6	2	5	1	2	3	3
45	10	6	6	5	2	1	9	8	3	4	7	6	5	4	2	6	2	3	3	6	4	6
46	138	3	5	1	3					4		2	2	2	1	2	2	6	3	6	3	6
47	212	6	7	1	2								3	6	6	6	6	6	1	6	6	6
48	59	6	6	3	7	3	4	4	2	4		4	3	2	1	2	2	6	3	3	3	6
49	32	6	6	1	3		4	5				2	3	3	2	1	1	2	3	3	4	4
50	77	4	5	2	1	8	6	5	9	7	4	3	3	3	2	2	1	6	2	3	3	3
51	132	6	7	2	1	6	5		3	7		4	3	2	1	6	1	6	1	2	2	6
52	14	6	5	2	3	5	6		1	7		4	6	5	1	4	6	6	1	5	5	6
53	5	6	6	2	1	9	5	8	4	6	7	3	3	3	1	1	1	4	1	2	3	3

Appendix C: Engineer Responses

	Qstn #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	I.D. #																						
54	13	3	2	1	1	2	3	1	3	3	2	5	4	5	1	6	1	2	3	6	3	5	5
55	253	5	9	1	2	3	3	4	2	3	4	4	3	5	1	1	1	3	2	6	4	6	5
56	140	3	2	1	1	1	3	1	2	3	2	5	3	2	2	5	3	3	3	2	7	1	2
57	206	3	2	1	5	1	1	1	4	2	3	4	3	1	1	6	5	2	2	2	7	3	6
58	42	5	2	1	3	1	3	1	2	3	1	5	2	5	1	3	1	4	2	6	7	5	6
59	290	2	5	1	5	1	1	2	3	2	2	3	3	4	4	6	4	2	2	4	4	3	5
60	85	3	2	1	1	2	3	1	2	1	2	5	2	4	1	6	1	1	1	6	7	6	6
61	24	3	5	1	1	1	2	2	2	3	3	5	3	4	1	5	1	2	2	5	5	6	7
62	105	3	2	1	5	2	1	1	2	2	2	3	3	1	3	6	3	4	3	5	5	5	2
63	241	4	2	1	1	2	2	1	3	3	1	4	5	5	2	1	2	2	2	6	3	3	5
64	180	3	2	1	1	4	3	1	3	3	4	5	4	4	1	3	1	3	2	4	2	7	5
65	213	2	4	1	5	1	1	2	1	1	2	4	2	1	6	6	5	2	2	6	6	6	6
66	231	3	2	1	1	2	2	1	1	2	2	4	3	5	6	6	3	3	3	3	4	1	4
67	108	2	5	1	5	3	1	2	1	1	2	5	3	1	6	6	6	3	3	5	7	3	3
68	310	5	1	1	3	1	3	3	2	4	2	5	4	5	1	1	1	2	2	5	5	3	6
69	30	3	5	1	1	2	2	2	2	2	2	4	3	2	3	4	3	2	2	5	6	3	4
70	78	3	8	1	1	2	3	6	3	3	3	1	3	5	2	6	2	4	2	6	2	6	6
71	65	6	1	1	3	3	2	2	2	4	4	3	3	5	1	4	3	3	2	5	2	3	5
72	35	3	2	1	1	2	2	1	3	2	3	3	4	4	3	4	3	1	2	6	6	6	6
73	50	3	5	1	1	2	3	2	1	3	4	4	3	1	3	6	3	1	1	7	4	7	6
74	296	3	4	1	1	2	3	3	2	3	4	5	3	1	4	3	3	2	2	6	4	6	5
75	326	4	9	1	2	3	3	2	2	3	3	4	3	5	1	3	1	3	1	6	5	2	6
76	126	3	3	1	1	2	2	2	3	3	3	3	3	3	4	6	5	2	2	5	5	6	5
77	288	4	2	1	1	2	3	1	2	3	4	5	3	5	1	6	3	3	3	5	3	5	7
78	300	3	2	1	1	2	3	1	3	1	4	5	4	5	1	4	2	2	1	3	5	2	7
79	291	3	2	1	5	2	2	1	1	2	2	3	3	4	1	3	1	3	2	6	1	5	4
80	298	3	5	1	1	1	2	2	2	2	2	5	3	5	1	6	1	4	3	3	6	3	3
81	234	1	3	1	5	1	1	3	1	1	1	4	3	1	6	6	6	2	2	4	4	2	5
82	204	3	9	1	5	1	2	1	2	1	2	3	2	2	1	6	3	2	2	6	5	3	5
83	218	3	2	1	1	2	3	1	2	3	4	5	3	4	1	6	2	2	2	6	4	5	6
84	20	3	3	1	5	1	2	3	2	1	2	2	3	3	2	6	1	2	2	7	4	7	6
85	271	3	2	1	1	1	2	1	3	1	2	3	3	4	2	6	6	1	1	7	3	5	6
86	67	1	9	1	5	1	1	2	2	1	1	5	2	1	6	6	3	2	2	6	7	4	6
87	303	3	5	1	1	2	3	2	3	3	4	3	3	3	4	6	5	3	2	6	5	6	5
88	17	1	9	1	5	3	1	8	1	1	1	3	2	2	3	6	3	3	2	6	3	5	4
89	104	3	2	1	1	1	1	1	3	1	3	3	3	3	2	4	2	2	1	7	5	7	6
90	54	5	6	1	2	1	2	2	2	3	3	5	3	5	1	3	1	2	2	6	5	6	6
91	208	5	1	1	3	3	3	3	2	3	4	4	3	5	1	5	1	1	2	7	3	7	6
92	162	2	9	1	5	3	1	1	3	2	2	5	3	4	2	6	3	2	2	6	2	6	6
93	93	3	2	1	1	1	1	1	2	1	2	4	3	2	5	6	4	2	1	5	7	6	6
94	116	3	3	1	1	1	1	2	2	1	1	3	2	4	6	6	1	2	2	3	3	6	6
95	125	3	5	1	1	1	3	2	2	3	3	5	1	1	6	5	3	3	3	2	5	1	3
96	79	3	8	2	1	1	2	3	3	3	3	5	4	2	2	2	2	1	1	6	6	6	6
97	259	5	1	1	3	1	3	3	2	2	4	5	3	5	1	1	1	1	1	6	1	5	7
98	254	1	3	1	5	1	1	3	1	1	2	5	2	1	6	6	6	2	3	5	7	6	5
99	274	3	5	1	1	2	3	3	2	3	4	2	3	5	4	5	3	4	3	3	6	3	6
100	143	4	9	1	2	2	3	8	2	3	4	5	4	5	1	3	1	2	1	6	3	6	6
101	90	3	2	1	1	2	3	1	2	3	3	3	3	5		2	1	3	1	6	1	1	7
102	328	4	4	1	1	3	3	7	2	2	3	5	5	3	1	4	1	2	2	7	3	3	7
103	40	4	5	1	1	3	2	4	2	3	2	4	3	5	3	4	3	3	2	6	4	3	6
104	92	1	5	1	5	1	1	2	2	1	2	5	2	1	4	6	4	2	2	7	7	7	5
105	267	3	8	1	1	1	2	8	2	3	3	5	3	5	3	4	1	2	1	7	5	7	7
106	141	3	2	1	5	2	2	1	2	2	2	5	3	1	5	5	5	3	2	5	6	2	5
107	167	1	3	1	5	1	1	3	3	1	2	4	3	1	6	6	6	3	2	6	6	7	6
108	96	3	8	1	1	1	2	1	3	3	2	3	3	5	1	2	1	2	1	7	1	7	7

Appendix C: Engineer Responses

	Qstn #	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
	I.D. #																					
54	13	6	6	1	4	5	6	9	3	8	7	2	3	3	2	3	2	4	2	3	4	3
55	253	6	6	2	8	5	7	9	3	6	4	1	1	3	2	1	2	6	2	4	3	2
56	140	2	2	1	6	9	7	8	5	4	3	2	2	2	2	1	1	2	3	4	3	1
57	206	6	6	2	1			3	4			5	4	4	1	3	3	6	1	6	4	4
58	42	6	5	2	1	4	5	6	7			3	5	2	6	6	1	6	1	1	6	6
59	290	4	7	1	4	3	6	5	7	9	8	2	2	4	3	4	2	3	3	4	5	5
60	85	6	7	1	4	5	6	9	2	7	8	3	3	4	3	2	1	6	2	2	3	3
61	24	7	7	1	3	9	5	6	4	7	8	2	3	3	2	1	1	3	2	3	3	3
62	105	1	2	2	1	8	5	7	6	3	9	4	3	4	6	6	6	6	3	6	4	6
63	241	5	5	2	6	5	7	4	8	9	3	1	3	2	1	6	1	2	2	2	4	1
64	180	5	4	1	4	3			5			2	5	4	2	6	1	3	3	4	4	4
65	213	6	7	3	1				4	5		2	3	3	2	6	1	6	1	6	3	6
66	231	4	5	4	3		6		7	5	2	1	3	4	2	1	1	3	3	4	3	2
67	108	5	5	1	3				4	5		2	3	4	2	2	1	6	6	6	3	6
68	310	3	5	6	3	3	3	5	6	2	2	6	3	3	6	6	6	2	2	3	5	4
69	30	4	5	7	6	5	4		2	3		1	4	3	2	1	1	6	3	3	3	6
70	78	6	6	5	2	8	6	9	7	4	3	1	4	2	3	6	1	6	2	4	3	2
71	65	5	5	1	5	9	3	2	4	7	8	6	3	2	2	2	2	3	3	2	3	3
72	35	6	6	1	7	3	5	6	2	9	8	4	5	4	1	2	2	3	3	3	4	4
73	50	6	7	1	3	9	4	8	7	6	5	2	4	3	1	1	1	4	1	3	3	3
74	296	5	7	8	7	5	2	1	6	3	4	9	3	3	1	1	1	2	1	4	3	3
75	326	7	6	3	1	7	9	8	6	5	2	4	3	3	3	2	2	2	1	5	4	3
76	126	6	6	2	1	3	5		4	7	6	8	3	3	1	2	2	3	2	3	3	3
77	288	6	6	4	8	5	6		6	5	5	6	3	2	2	6	2	6	2	3	3	3
78	300	7	7	3	2	4	5	6	1	7	8	9	2	3	1	6	1	2	1	3	4	4
79	291	4	6	6	1			2	7	4	3	5	4	2	2	1	2	6	3	3	2	2
80	298	5	5	3	2	7	6		1	5		4	4	2	1	6	1	6	2	3	2	6
81	234	5	3	2	1	8	7	6	5	4	9	3	3	6	2	6	1	1	1	6	6	6
82	204	6	6	3	2				4	5		1	2	3	1	6	2	6	2	6	3	6
83	218	6	6	1	6	5	4	0	2	8	7	3	4	3	1	2	2	4	3	3	4	4
84	20	6	7	1	2							3	4	4	4	6	2	3	2	6	4	6
85	271	6	7	2	4	1	6	7	5	8	9	3	3	3	1	3	2	2	2	4	3	3
86	67	6	6	2	1	3						4	3	6	1	1	2	6	2	6	6	6
87	303	5	6	1	3	7	2	9	4	6	8	5	5	3	6	1	3	4	2	2	4	4
88	17	5	6	1	2			3	4	8			6	3	2	6	3	6	2	1	3	6
89	104	6	7	1	1	7	7		1	5		2	4	5	1	1	2	3	1	4	4	
90	54	6	7	3	2	4	6	5	1	8	7	9	3	2	1	2	2	3	1	3	4	3
91	208	6	6	1	4	7	9	5	3	8	6	2	3	2	1	1	1	6	2	3	3	2
92	162	6	5	5	4	1	8	7	6	2	9	3	1	1	1	1	1	1	2	6	1	6
93	93	6	7	4	1	6	2			5		3	2	2	3	1	6	6	2	3	3	6
94	116	6	5	1	3	5	4	9	2	6	7	8	3	2	1	1	2	3	2	3	4	4
95	125	3	6	1	9	8	4		5	6	7	2	6	3	1	6	1	6	3	2	3	3
96	79	6	6	4	1	3	5			7	6	2	3	4	6	3	3	2	2	3	4	4
97	259	7	6	3	5	1	8	6	4	9	7	2	3	3	1	2	1	6	2	3	3	3
98	254	5	6	7	1				9	6			4	3	5	3	6	6	2	6	3	6
99	274	3	5	2	5	6	7	7	3	8	8	2	4	3	2	2	2	3	3	3	3	3
100	143	6	6	2	3	4	8	7		6	5	1	6	4	6	6	2	6	2	4	3	3
101	90	6	6	1	4	5	6		3	7		2	2		1	1	1	4	2	4		
102	328	7	7	3	7	4	6		2	5		1	5	2	2	6	1	1	3	4	3	6
103	40	5	7	1	3	6	8		4	7	5	2	2	3	3	6	2	6	2	4	3	2
104	92	5	6		1	3			5	4		2	3	3	3	6	6	6	2	6	3	6
105	267	7	7	1	7	5	3	9	6	8	4	2	3	1	2	6	1	6	2	2	3	1
106	141	5	6	5	4				1	3		2	3	3	2	6	6	6	4	6	3	6
107	167	6	7	1	4			5	2	3			3	2	1	6	6	2	2	6	3	6
108	96	7	7	2	1	6	8	0	3	7	5	4	4	3	1	3	1	5	1	5	4	4

Appendix C: Engineer Responses

	Qstn # I.D. #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
109	144	2	9	1	5	1	1	8	1	1	2	5	3	4	3	5	1	3	3	3	6	3	2
110	192	5	2	1	2	3	2	1	2	3	3	5	3	5	1	6	3	2	1	6	3	6	5
111	193	1	2	1	5	1	1	1	2	2	1	5	1	2	1	4	2	3	2	6	7	7	6
112	183	3	2	2	1	2	2	1	2	1	2	3	2	1	4	6	3	3	3	5	7	3	5
113	196	4	2	1	2	1	2	1	3	4	1	2	3	3	3	5	2	2	1	7	6	7	4
114	210	3	3	1	5	2	2	3	2	1	2	3	2	3	1	5	4	4	3	3	1	2	6
115	283	4	5	1	2	3	2	3	2	3	3	5	3	5	1	6	2	2	2	5	2	3	4
116	2	3	5	1	5	1	2	2	3	3	2	5	3	5	1	1	1	2	2	6	6	6	6
117	110	3	3	1	1	1	1	4	3	1	1	4	3	2	2	6	3	3	3	3	4	4	4
118	195	3	9	1	1	2	3	1	3	3	2	5	3	4	1	5	1	1	1	1	1	3	7
119	325	4	5	1	1	1	3	2	2	2	2	5	3	2	2	5	2	3	3	4	4	4	4
120	222	3	2	1	1	2	2	1	3	2	2	3	4	1	6	6	6	1	1	2	1	7	6
121	127	4	2	2	1	1	3	1	2	2	2	5	3	3	1	6	2	2	2	5	4	1	5
122	160	1	9	1	5	3	1	8	2	1	2	4	3	3	3	5	4	2	2	6	7	6	6
123	178	3	8	1	5	1	2	2	2	2	3	4	3	4	4	5	3	2	2	5	6	2	5
124	299	3	2	1	1	2	2	1	2	1	3	3	2	2	2	6	2	3	2	6	7	4	5
125	245	2	9	2	5	1	1	8	1	1	2	5	2	4	1	5	1	3	2	6	5	6	7
126	304	3	5	1	5	1	2	2	2	3	3	4	3	3	4	5	3	2	2	6	7	3	5
127	169	3	2	1	5	1	2	1	2	1	3	5	4	5	1	3	1	3	3	5	6	3	3
128	324	3	9	1	1	2	3	1	3	1	2	4	4	5	1	4	1	1	1	6	3	6	7
129	139	3	2	1	1	2	2	1	2	2	3	5	1	4	1	3	3	4	3	2	6	3	4
130	233	5	1	1	3	3	2	2	2	2	4	5	3	5	1	1	1	4	2	2	1	2	6
131	118	3	2	1	1	2	2	1	3	3	4		4	5	2	6	1	1	2	6	2	5	5
132	285	3	2	1	1	2	2	1	1	2	2	3	3	2	4	6	4	4	2	6	4	5	3
133	214	3	4	1	1	3	3	7	2	3	3	5	3	1	6	6	6	1	1	6	6	7	6
134	163	4	2	1	2	2	2	1	1	4	1	3	3	4	1	5	4	2	1	6	7	7	7
135	273	1	9	1	4	2	1	8	2	1	2	5	3	4	2	4	2	2	2	6	7	3	5
136	269	3	3	1	1	2	2	3	3	2	3	4	4	1	6	4	5	1	3	6	7	7	3
137	230	3	9	1	1	3	2	1	3	1	2	4	4	3	1	6	2	3	3	2	4	2	3
138	211	3	8	1	5	1	2	3	3	3	3	5	4	4	3	4	3	1	1	7	3	6	7
139	263	3	8	1	1	3	2	1	2	3	3	5	4	4	1	3	1	3	2	6	3	6	6
140	270	3	9	1	1	1	3	2	3	3	4	5	4	1	1	4	2	3	2	5	1	2	6
141	37	3	5	1	1	1	3	2	2	3	4	5	4	5	1	1	1	4	1	7	4	3	7
142	239	3	9	1	1	1	1	1	2	1	2	5	3	3	1	5	3	2	1	6	3	6	7
143	308	3	9	1	1	2	2	1	2	3	3	5	2	5	3	3	2	2	2	5	4	5	6
144	111	3	2	1	5	3	2	1	2	3	2	4	3	3	2	4	4	2	2	7	6	6	6
145	166	3	2	1	1	2	3	1	3	3	4	5	4	5	1	2	2	3	2	4	3	1	6
146	217	4	9	1	1	2	3	2	2	3	3	5	3	5	1	2	2	2	1	7	6	6	6
147	203	3	5	1	1	1	3	2	2	2	4	4	3	4	2	5	3	3	3	3	6	3	5
148	236	1	9	1	5	3	1	8	1	1	1	5	4	5	6	6	6	3	2	4	4	2	4
149	246	3	8	1	1	2	3	6	3	3	4	3	3	2	6	5	3	4	3	3	2	3	5
150	107	3	5	1	1	1	2	2	2	1	2	5	3	4	6	6	1	2	1	7	7	7	7
151	258	3	5	1	5	1	1	2	2	2	2	5	3	1	3	6	6	1	3	7	7	7	5
152	265	1	2	1		1	1	1	1	1	1	4	2	1	6	6	6	3	3	3	5	3	4
153	319	3	5	1	1	2	3	2	2	2	4	5	3	5	6	4	3	4	[illegible]	4	4	5	5
154	279	4	1	1	2	1	3	2	2	3	4	5	3	1	6	6	6	1	1	6	2	7	7
155	172	3	2	1	1	2	2	1	3	3	3	5	3	4	1	5	3	2	2	6	1	5	5
156	16	3	2	1	1	2	2	1	2	1	2	4	2	1	2	4	2	3	3	4	7	2	5
157	301	3	8	1	1	1	2	1	3	3	3	4	4	5	1	3	1	1	2	6	1	7	5
158	294	3	5	1	1	1	2	2	2	1	2	5	4	4	1	6	3	3	3	6	7	3	3
159	173	2	9	1	5	1	1	1	1	2	2	4	3	1	3	6	3	2	2	7	5	3	6
160	55	3	2	1	1	2	2	1	2	2	2	4	2	4	5	5	3	4	3	5	4	2	5
161	289	6	1	1	2	2	3	2	3	1	3	5	3	5	6	6	1	2	2	7	7	7	7
162	154	3	2	1	4	2	2	1	2	2	2	5	2	1	6	4	4	1	3	7	7	2	6
163	164	5	1	1	2	1	3	1	2	3	4	5	3	5	1	4	3	1	1	7	4	6	6
164	219	3	2	1	1	2	3	1	3	3	1	2	3	4	4	4	1	3	2	5	6	5	6

Appendix C: Engineer Responses

	Osln # I.D. #	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
109	144	2	4		1					3		2	6	3	2	1	2	6	3	6	3	6
110	192	5	5	1	5	9	6	4	3	8	7	2	3	2	1	2	1	4	1	2	2	2
111	193	6	6	7	8	6		3		2		1	4	6	6	4	4	6	2	6	5	6
112	183	4	5	8	9		1			2		3	6	3	6	6	3	6	3	3	3	6
113	196	3	7	5	8	6	5	5	6	1	1	8	4	4	2	4	5	6	5	4	6	6
114	210	2	3	1	3				2	4			2	3	1	2	1	2	2	2	3	6
115	283	4	4	1	3	9	7	8	4	6	5	2	4	3	1	1	1	6	2	3	3	3
116	2	6	6	5	7	6	8	9	4	2	3	1	3	2	2	3	2	2	2	2	2	2
117	110	3	5	1	7	5	2	6	4		3	3	2	2	3	1	3	4	3	2	6	
118	195	7	7	1	4	3	5		8	7	6	2	3	4	1	3	2	2	2	5	5	5
119	325	3	3	2	1	6	4	7	3	5	8	9	5	3	2	2	2	3	2	2	2	2
120	222	6	7	2	4	5	7	8	3	6		1	3	3	1	1	2	3	2	4	3	6
121	127	5	6	2	3	8	6		7	4	5	1	4	3	3	2	2		2	3	3	3
122	160	6	7		2				4	3		1	4	4	1	1	6	6	3	6	4	6
123	178	4	6	6	1		3		5	4		2	3	3	3	6	2	6	2	3	3	6
124	299	5	7	3	4	7	5	6	2	8		1	4	2	1	6	2	3	2	2	3	6
125	245	6	7	6	1			5	3	4		2	3	2	1	6	1	2	1	6	3	6
126	304	5	6	2	3	4			7	6	5	1	3	3	2	3	2	3	2	6	4	3
127	169	3	3	3	6	2				4	5	1	3	3	3	6	3	2	3	6	3	3
128	324	6	6	3	4	1	5	6	2	8	7	9	3	1	2	2	2	1	1	2	3	2
129	139	4	4	4	6	5	3		0	2		1	5	2	1	3	2	5	3	3	2	6
130	233	6	6	1	3	5	9	8	4	7	6	2	5	3	2	2	2	6	1	3	3	3
131	118	5	5	1	3	2	8	9	5	7	6	4	4	2	2	1	6	2	1	4	6	3
132	285	6	6	2	4		6		1	5		3	4	2	1	1	2	4	2	4	2	6
133	214	6	6	1	6	3	7			5	4	2	4	2	6	5	1	6	3	5	3	2
134	163	7	7	2	1		4	5		6	7	3	4	2	6	1	2	6	1	2	2	2
135	273	5	6	1	2			3		4		5	2	4	3	2	6	3	3	3	4	6
136	269	3	6	1	3	4	7	9	2	8	6	5	3	4	1	2	1	3	1	3	4	3
137	230	2	6	1	3	5	7		4	6		2	3	3	1	2	2	2	2	3	4	6
138	211	7	7	3	4	2				6	5	1	3	5	4	6	1	2	2	6	5	5
139	263	5	6	4	3	6	5	9	2	7	8	1	3	3	3	6	2	6	3	3	4	4
140	270	6	5	2	1	6	3	4	3	7	8	9	4	3	1	3	1	4	1	3	3	3
141	37	7	7	3	1	4	8		2	7	6	5	3	4	1	1	1	2	1	5	4	4
142	239	7	6	1	4	6	5	9	2	8	7	3	4	3	1	2	2	6	1	3	4	4
143	308	6	6	2	3	6	5		1	8	7	4	3	2	1	2	2	3	2	2	3	2
144	111	6	6	5	6	4	3	9	2	7	8	6	1	3	2	2	2	2	1	2	3	3
145	166	6	6	3	2	4	5	6	1	9	8	7	3	3	1	3	1	2	2	3	3	3
146	217	7	6	2	4	5	7		1	8	6	3	3	3	1	4	1	2	1	3	3	3
147	203	5	6	1	6	9	4	8	3	7	5	2	4	3	2	6	2	6	3	3	5	3
148	236	4	4	4	3	9	7	8	2	5	6	1	3	3	1	1	1	3	2	6	3	6
149	246	5	5	1	3	7	5	8	4	9	6	2	2	3	2	2	1	6	2	3	4	3
150	107	7	7	2	3		5		1	6		4	1	4	1	6	1	6	1	3	4	6
151	258	5	7	1	2							3	6	4	6	3	6	6	2	6	4	4
152	265	4	5		5				3	4		6	3	3	2	2	2	3	3	3	3	6
153	319	5	6	1	2	7	6			5	4	3	4	2	2	1	2		2	3	3	2
154	279	7	7	4	1	5	6	7	3	9	8	2	2	3	1	1	3	3	2	2	3	3
155	172	7	7	1	3	2	7	6	4	8	9	5	3	5	2	1	2	3	2	5	5	5
156	16	4	5	4	1	6	3	9	2	7	5	8	3	3	1	6	3	3	2	1	4	3
157	301	6	7	2	4	3	5			7	6	1	4	3	6	1	1	2	1	3	4	3
158	294	3	6	3		4	1			5		2	4	5	5	6	4	6	3	4	5	6
159	173	6	6	1	2				3	5		4	5	4	1	1	6	3	3	6	4	6
160	55	3	6	1	5	7	3		6	4		2	3	3	4	2	1	4	3	3	3	6
161	289	7	7	1	2	3	8	7	5	9	6	4	3	3	3	1	1	2	1	5	4	3
162	154	5	7	1	2	3	8	6	4	9	7	5	1	4	1	2	1	1	1	4	5	6
163	164	6	7	3	2	4	8	9	7	6	5	1	3	2	3	3	2	6	2	3	3	2
164	219	5	5	9	8	6	4	5	3	1	2	7	4	4	2	3	2	3	3	2	4	3

Appendix C: Engineer Responses

	Qstn #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	I.D. #																						
165	91	3	8	1	1	1	2	2	3	3	3	4	4	4	4	4	3	2	1	7	2	7	7
166	155	3	2	1	5	3	2	1	2	3	3	5	4	4	3	5	2	1	2	6	2	5	6
167	207	3	5	1	1	1	2	2	2	2	3	5	2	1	2	5	3	3	2	5	5	2	7
168	322	3	2	1	5	1	2	1	2	2	2	3	3	5	1	3	1	2	1	6	1	5	7
169	8	3	3	1	1	1	3	3	3	3	2	2	3	5	3	5	1	1	2	7	1	7	7
170	102	4	2	1	1	2	3	1	3	3	2	5	4	3	1	1	1	2	2	7	7	6	7
171	22	4	6	1	2	3	2	2	3	3	3	3	3	5	1	5	2	2	2	3	7	3	6
172	23	2	9	1	5	3	1	3	2	2	2	4	3	1	3	6	1	2	1	6	4	7	5
173	198	3	8	1	1	2	2	6	2	1	1	4	4	4	6	6	5	2	1	7	5	6	6
174	122	3	2	1	5	1	2	1	1	2	2	3	2	4	2	6	2	2	2	5	5	2	6
175	87	3	2	1	1	2	2	1	2	1	2	5	2	1	6	6	4	2	2	3	7	1	3
176	205	1	2	2	5	2	1	8	1	1	1	4	2	2	2	6	6	3	2	3	3	2	6
177	130	3	8	1	1	1	3	1	2	1	2	5	3	3	1	6	2	2	2	7		3	7
178	7	3	4	1	1	2	2	2	3	3	1	2	3	5	1	3	1	3	2	6	4	2	6
179	48	5	9	1	2	4	3	2	2	2	4	4	3	5	1	3	2	3	3	2	5	6	6
180	34	3	8	1	1	3	1	8	2	2	2	4	4	3	1	5	2	3	2	6	2	2	7
181	98	3	8	1	5	3	1	1	1	1	2	3	3	4	2	4	1	1	2	7	3	7	6
182	292	3	9	1	1	2	3	3	3	3	2		4	5	2	6	1	2	1	5	3	6	6
183	311	4	5	2	1	1	3	2	3	4	4	5	3	1	1	6	3	3	3	4	4	7	5
184	313	3	9	1	1	2	3	2	3	3	1	5	4	5	1	2	1	2	2	6	5	6	5
185	312	5	1	1	2	1	3	8	3	3	4	5	4	4	1	2	1	2	1	6	7	5	6
186	113	3	5	1	1	3	3	2	2	3	4	5	4	5	1	2	1	3	2	5	5	2	5
187	179	3	3	1	1	1	3	3	2	2	3	5	3	5	1	5	1	3	3	2	3	1	5
188	264	3	5	1	1	1	1	2	3	2	2	3	4	4	6	6	2	2	2	6	4	6	7
189	243	3	2	1	1	1	2	1	2	1	2	5	2	3	4	6	2	3	2	5	4	6	6
190	216	3	2	1	4	2	2	1	2	1	2	5	3	3	2	6	1	3	2	4	4	3	6
191	272	4	2	1	1	2	2	1	2	1	2	4	1	5	3	6	1	4	3	2	6	1	4
192	276	3	5	1	1	2	2	2	1	1	2	3	3	2	2	6	4	4	3	3	4	2	4
193	315	1	8	1	5	1	1	2	2	1	2	4	2	2	4	3	1	4	3	7	6	7	6
194	226	3	3	1	1	1	2	3	2	1	2	4	3	5	1	3	1	4	2	7	4	5	5
195	159	3	9	1	1	1	3	2	2	1	2	5	3	1	6	6	6		2			7	6
196	142	3	2	1	1	1	1	1	3	2	2	4	4	2	2	6	4	4	2	5	6	5	6
197	232	1	9	1	5	3	1	3	1	2	2			4	4	4	2	3	2	5	3	3	5
198	72	1	4	1	4	1	1	8	1	1	2	3	3	1	6	6	6	2	2	4	7	7	4
199	89	3	3	1	1	1	2	3	2	1	2	5	2	5	2	5	1	3	2	6	4	3	6
200	33	3	2	1	5	2	2	1	3	3	2	2	4	5	1	2	1	2	2	6	6	6	6
201	323	5	1	1	2	1	2	1	2	3	2	4	3	4	1	2	3	3	2	6	1	6	6
202	293	4	9	1	2	1	3	1	3	3	4	5	5	5	1	5	2	1	1	7	3	3	6
203	177	3	2	3	4	2	2	1	1	1	2	5	2	5	1	6	1	4	1	6	1	5	7
204	94	3	2	1	1	2	3	1	2	2	2	3	2	1	6	6	4	3	1	1	4	4	4
205	182	3	2	1	1	2	2	1	3	3	2	4	4	5	1	4	3	2	3	3	4	3	4
206	284	3	9	1	1	3	3	8	3	3	4	4	4	5	1	3	1	1	1	6	1	2	6
207	318	3	5	1	1	1	3	2	2	3	4	5	4	5	2	3	1	3	2	5	2	1	7
208	248	2	5	1	5	1	1	2	1	1	2	3	2	3	3	6	4	3	3	4	3	3	4
209	71	1	9	1	5	1	1	3	2	2	2	5	3	4	6	1	1	2	2	7	4	1	7
210	56	1	2	1	5	1	1	1	2	1	1	5	2	2	6	6	2	3	3	5	4	2	4
211	201	2	5	1	5	1	1	2	3	6	6	4	3	1	5	5	6	3	2	6			
212	237	3	3	1	1	2	2	3	2	2	3	5	3	5	1	1	1	2	2	3	7	2	5
213	145	3	5	1	1	2	3	2	3	1	2	4	3	4	2	5	1	3	3	5	7	6	6
214	221	4	9	1	1	2	3	1	2	1	3	5	3	2	2	5	3	3	2	6	6	6	4
215	277	5	1	1	3	1	3	2	3	3	4	4	4	5	1	2	1	2	2	3	5	3	5

Appendix C: Engineer Responses

	Qstn # I.D. #	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
165	91	7	7	1	3	8	5		2	6	7	4	1	3	1	2	1	3	1	2	3	3
166	155	6	5	5	1	3	9	8	4	7	6	2	1	3	2	6	2	1	1	6	3	3
167	207	5	6	4	1	5	2			6		3	4	3	2	3	1	1	1	2	5	4
168	322	6	7	2	3	7			6	5	4	1	2	2	6	6	1	1	1	2	3	3
169	8	7	7	1	2	7	8	9	4	6	5	3	5	3	1	6	1	5	2	5	3	3
170	102	7	7	1	4	7	8	9	6	3	2	5	1	2	1	4	1	1	2	4	1	7
171	22	6	7	1	2	6	9	5	3	8	7	4	2	3	1	1	1	4	1	4	5	4
172	23	5	7	8	7	6	6	6	7	2	2	8	3	5	2	2	2	6	2	6	5	6
173	198	6	7	3	1	2	7	9	8	6	5	4	3	3	2	3	1	2	1	3	2	2
174	122	6	5	1	3	8	7	9	2	5	6	4	3	4	1	3	2	3	2	3	3	3
175	87	4	3	3	8	2	1	9	4	7	6	5	4	3	1	6	2	2	2	1	4	4
176	205	6	6	2	4			5	3	6		1	2	2	2	2	2	6	2	6	3	6
177	130	5	5	1	4	5	6		3	8	7	2										
178	7	6	6	2	1	4	8	9	5	6	7	3	3	6	2	6	2	3	2	3	6	6
179	48	6	6	1	2	3	9	8	4	7	6	5	3	3	2	3	1	6	2	5	4	3
180	34	6	5	1	4	2	3						2	3	3	1	3	3	2	3	3	3
181	98	6	7	3	1			2	4	6		5	4	4	2	2	2	6	2	6	4	6
182	292	6	7	2	5	1	9	3	7	6	4	4	4	2	2	6	2	1	2	5	3	2
183	311	6	3		1	2	3			4	5	6	3	4	6	3	6	3	2	4	4	4
184	313	6	5	1	2	3	4	8	5	6	9	7	3	3	1	6	1	2	2	3	3	6
185	312	6	6	1	3	4	5	8	9	7	6	2	3	3	3	1	1	2	2	3	3	3
186	113	7	7	1	3	4	9	8	5	7	6	2	2	3	2	4	2	3	1	4	3	3
187	179	6	3	1	3	9	4	6	5	7	8	2	4	4	2	3	1	6	3	3	4	4
188	264	7	7	2	8	1	3		4	5		6	6	3	1	6	6	1	1	1	2	6
189	243	6	5	1	4	5	2			6		3	5	4	6	6	6	6	2	2	5	6
190	216	6	6	1	3	3	5	5	2	7	5	2	3	4	1	1	3	6	3	4	4	6
191	272	4	5		6	2	3	0	4	5		1	4	3	2	3	3	6	3	3	2	6
192	276	5	4	1	2	6	5	7	3	9	8	4	4	3	2	1	1	3	2	3	4	4
193	315	6	7	1	4				2	5		3	4	4	1	6	1	2	2	6	4	6
194	226	5	7	1	3	4	5			6		2	3	4	3	6	2	6	2	3	5	6
195	159	6	6		1		2						3	6	6	6	6	6	2	3	6	6
196	142	6	6	4	2	1	5	7	3	8	9	6	3	3	3	2	2	2	2	3	3	6
197	232	5	4	3	2			6	4	5		1	4	4	2	1	1	4	2	6	4	6
198	72	4	6	4	5			3	2	1			3	3	3	6	6	6	3	3	4	6
199	89	6	6	1	5		6		4	7	3	2	2	2	1	3	1	2	1	3	3	1
200	33	6	7	3	6	7	8	9	2	4	5	1	2	2	2	2	1	2	1	3	2	2
201	323	6	7	4	2	3	6	7	8	5	1	9	2	1	3	3	3	3	2	3	4	1
202	293	6	6	1	5	3	4	6	9	8	7	2	2	3	4	6	3	2	3	2	4	4
203	177	7	7	1	2			3	9	3	3	1	6	3	6	1	1	6	1	3	3	3
204	94	4	5	5	4	8	7	6	9	9	9	1	2	4	3	1	4	4	3	2	6	6
205	182	3	1	1	4	9	5	6	3	8	7	2	4	3	6	6	2	4	3	3	5	5
206	284	6	6	1	3	7	8	9	4	6	5	2	3	2	1	6	1	4	2	3	2	2
207	318	6	6	1	4	5	6		3	8	2	7	4	2	1	6	1	3	2	3	1	
208	248	3	5	1	2	4	3	5	6	9	8	7	2	3	2	2	1	3	3	3	3	3
209	71	7	7	1	2					4		3	1	3	1	1	3	3	2	6	4	6
210	56	4	6		3	4				2		1	4	2	1	6	6	6	2	6	3	6
211	201			4	1	2	5	6	7	3	8	9	3	6	3	6	2	2	2	6	4	6
212	237	5	6	1	2		6		5	4		3	3	3	2	1	1	6	3	5	3	6
213	145	6	6	2	1	6	7	9	8	5	4	3	3	3	3	6	3	3	3	5	4	3
214	221	4	6	2	3	7	9	8	4	6	5	1	3	3	6	1	2	3	2	3	3	3
215	277	5	5	1	3	4	8	5	2	7	6	9	3	3	1	2	2	3	3	4	4	4

Appendix D: Supervisor Responses

RTN#	Qstn # I.D. #	1	2	3	4	5	6	7
1	16	6	3	5	2	4	4	6
2	60	7	7	2	7	7	7	7
3	98	6	2	5	5	5	2	6
4	130	7	6	2	3	3	2	6
5	191	7	6	2	6	6	6	6
6	252	6	6	6	6	6	6	7
7	104	7	6	7	6	7	7	7
8	216	1	4	6	6	4	4	6
9	46	7	6	6	3	5	5	3
10	226	7	6	6	3	5	5	3
11	72	1	7	7	7	4	4	7
12	272	6	6	7	6	5	5	6
13	162	1	7	7	3	6	5	5
14	48	5	5	3	3	6	5	6
15	93	4	6	6	3	4	4	3
16	143	7	6	2	5	4	4	3
17	296	1	7	7	7	7	7	7
18	279	5	0	3	5	7	3	3
19	222	1	4	5	3	7	5	6
20	79	5	7	3	6	6	7	6
21	259	7	7	4	7	7	6	7
22	295	6	6	5	6	5	5	6
23	269	4	3	5	3	5	4	4
24	20	7	7	7	7	7	7	7
25	43	7	7	5	7	7	7	7
26	245	6	6	5	4	0	0	7
27	225	5	5	6	5	5	5	5
28	260	6	7	6	7	7	7	7
29	300	5	7	6	6	7	6	7
30	318	6	5	3	4	4	3	4
31	298	7	6	3	5	6	6	5
32	150	3	3	3	3	5	3	3
33	218	7	6	3	3	6	6	5
34	204	2	2	6	2	6	5	3
35	173	1	7	7	6	6	6	7
36	200	2	6	4	7	7	6	7
37	328	5	7	5	7	7	7	7
38	275	5	7	5	7	7	7	7
39	19	7	6	2	7	6	6	6
40	284	7	7	2	7	6	6	7
41	119	2	2	6	2	2	3	3
42	147	2	7	7	7	5	6	6
43	157	6	6	4	7	7	7	7
44	310	7	3	4	2	3	2	2
45	194	7	6	2	6	5	6	6
46	131	1	4	6	4	4	4	5
47	24	3	6	7	6	6	7	5
48	244	7	7	4	7	7	7	7
49	122	7	7	7	2	6	6	7
50	159	7	6	1	6	5	5	6
51	85	7	6	1	7	6	6	7
52	15	7	7	2	6	6	6	6
53	76	1	6	6	6	5	4	7
54	92	2	5	7	6	5	4	6
55	78	6	6	5	3	3	5	5

RTN#	Qstn # I.D. #	1	2	3	4	5	6	7
56	203	2	7	7	7	6	6	7
57	11	7	6	6	7	5	5	6
58	6	6	6	6	5	6	6	6
59	106	7	7	4	7	4	7	7
60	1	7	7	7	7	7	7	7
61	4	7	6	4	5	5	6	5
62	179	7	7	2	7	6	7	6
63	113	6	6	7	5	6	5	7
64	58	3	4	6	5	5	5	6
65	17	5	6	5	2	4	4	5
66	10	7	7	2	7	6	6	7
67	103	6	7	6	5	6	6	7
68	262	7	7	7	5	6	6	6
69	77	7	7	2	6	6	6	7
70	108	1	2	6	2	2	2	2
71	231	1	5	4	5	4	4	3
72	249	2	4	7	7	4	4	6
73	39	7	7	5	6	7	7	7
74	51	7	3	6	1	5	3	4
75	75	6	3	3	3	6	7	7
76	178	7	7	7	7	7	7	7
77	132	5	4	6	5	6	6	6
78	14	5	4	4	6	6	6	3
79	21	5	6	5	6	6	6	6
80	13	7	7	1	6	5	5	7
81	38	7	7	1	6	7	7	7
82	120	7	6	1	4	4	4	6
83	27	6	5	6	4	6	5	6
84	84	6	5	4	4	6	2	3
85	82	1	1	7	1	3	2	4
86	241	7	6	2	6	5	6	6
87	128	7	7	5	5	5	6	7
88	213	2	5	7	4	4	4	6
89	180	7	7	2	7	7	7	7
90	97	1	7	7	7	4	4	7
91	167	6	7	6	5	4	4	7
92	315	6	7	6	4	7	4	5
93	30	2	6	7	6	6	5	6
94	9	6	7	3	3	4	4	3
95	325	6	6	6	6	5	5	7
96	293	7	6	1	6	6	6	7
97	73	6	7	7	4	6	6	7
98	125	1	6	3	6	7	7	7
99	121	6	4	4	2	3	3	4
100	220	6	7	3	6	7	6	6
101	67	1	7	7	4	4	4	6
102	307	5	6	6	5	6	6	7
103	181	7	7	1	7	6	4	7
104	2	7	7	7	7	7	7	7
105	285	6	7	3	7	7	7	7
106	112	7	7	4	6	7	7	7
107	294	5	6	5	6	5	4	3
108	146	5	6	6	6	6	6	6
109	33	7	7	3	6	7	6	6
110	12	3	6	7	5	5	3	6

Appendix D: Supervisor Responses

RTN#	Ostn # I.D. #	1	2	3	4	5	6	7
111	271	6	6	4	6	6	4	5
112	126	7	7	7	7	7	7	7
113	303	6	6	4	6	6	4	6
114	314	1	6	7	7	4	4	6
115	287	7	4	2	2	3	3	3
116	23	5	3	7	2	3	3	5
117	304	6	7	6	7	7	7	0
118	28	7	7	7	1	3	3	7
119	170	6	6	3	3	5	6	6
120	316	7	5	6	3	6	5	5
121	32	5	6	7	7	7	7	7
122	118	7	6	6	2	6	6	4
123	264	6	6	6	3	5	5	4
124	91	2	4	5	6	4	4	5
125	217	6	7	6	7	7	7	0
126	31	2	7	7	6	4	4	4
127	168	6	7	2	7	7	7	7
128	35	2	5	6	4	4	4	6
129	291	2	5	6	6	6	7	7
130	144	1	4	6	4	4	4	5
131	214	1	6	6	7	4	6	6
132	273	6	6	7	7	4	4	6
133	236	2	6	7	3	4	4	5
134	283	6	7	3	6	6	6	6
135	110	3	5	7	3	4	4	6
136	163	5	5	7	6	5	6	6
137	201	1	4	7	7	6	6	7
138	276	1	4	7	7	4	6	7
139	246	6	6	2	7	6	7	7
140	312	7	7	2	7	7	7	7
141	136	3	5	6	3	3	4	5
142	301	7	6	4	5	6	6	6
143	109	7	7	2	6	6	6	7
144	45	7	6	3	6	7	6	5
145	55	5	5	4	3	3	3	5
146	288	6	6	3	5	6	6	6
147	227	5	5	5	3	5	5	3
148	101	3	5	5	3	5	5	4
149	169	6	5	3	4	5	5	5
150	322	4	6	5	6	5	5	5
151	182	4	6	5	4	6	6	6
152	155	6	4	5	3	4	5	6
153	86	3	4	6	3	4	4	5
154	324	6	7	5	6	7	7	6
155	255	6	7	6	7	7	7	7
156	239	6	6	5	7	7	7	7
157	250	7	7	5	7	7	7	7
158	305	6	6	2	5	6	6	7
159	233	7	3	6	1	3	3	3
160	205	1	1	6	1	6	5	6
161	44	6	6	3	4	3	6	7
162	139	3	6	2	6	6	6	7
163	229	3	5	7	5	6	6	6
164	206	5	6	5	7	7	7	7
165	115	1	4	7	3	5	4	3
166	238	1	4	7	6	4	4	5
167	281	6	7	7	7	7	6	7
168	230	3	5	7	2	7	7	7
169	64	2	5	7	2	6	6	7
170	207	6	7	5	6	7	7	7
171	177	7	2	5	1	7	3	3
172	142	2	5	5	3	4	4	5
173	195	3	7	6	6	7	6	7
174	306	7	7	5	6	6	5	6
175	311	6	7	5	6	6	6	6
176	172	7	5	7	3	4	4	6
177	251	7	5	7	3	4	4	6
178	29	7	5	7	3	4	4	6
179	247	7	5	7	3	4	4	6
180	111	7	5	7	3	4	4	6
181	5	7	5	7	3	4	4	6
182	8	3	7	4	6	6	6	7
183	313	7	7	4	6	7	7	7
184	96	7	7	4	6	7	7	7
185	212	3	6	5	3	5	5	6
186	87	2	7	7	7	6	6	6
187	326	7	7	5	7	6	7	7
188	141	6	3	5	2	2	2	2
189	198	7	7	7	6	4	4	7
190	34	6	5	6	4	3	2	1
191	286	2	5	7	6	4	4	6
192	135	4	6	7	6	6	6	6
193	183	6	2	6	2	1	3	5
194	80	7	6	6	6	6	6	7
195	278	7	7	6	7	7	7	7
196	47	6	6	7	3	4	4	3
197	256	7	7	2	7	7	6	7
198	56	1	4	7	6	4	4	6
199	282	7	7	4	7	7	7	7
200	140	5	2	7	2	1	1	1
201	145	5	5	6	5	6	6	6
202	107	4	5	5	4	6	6	5
203	165	1	3	6	3	5	3	3
204	153	1	7	6	6	5	6	7
205	321	3	6	6	6	7	7	6
206	235	6	5	5	4	5	4	3
207	164	7	6	6	5	6	6	7
208	66	6	7	4	6	7	7	7
209	123	3	6	6	6	7	7	6
210	37	3	6	6	6	7	7	6
211	148	3	6	6	6	7	7	6
212	152	7	7	3	7	7	7	6
213	280	5	6	7	6	6	5	6
214	290	2	6	6	6	6	6	6
215	41	4	4	6	6	5	5	3
216	59	7	5	6	2	6	5	7
217	210	5	6	7	7	5	5	5
218	174	5	6	7	7	6	6	7

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Vita

Captain Steven E. Woodruff was born on 14 September 1952 in Kalamazoo, Michigan. He graduated from Portage Northern High School in Portage, Michigan in 1970. He enlisted in the U. S. Air Force in 1976 and after completing training at Lowry AFB, Colorado in 1977 maintained and repaired AIM-9, AIM-7, AGM-45 and AGM-65 missiles, GBU-10/12/15 guidance and control units, and their associated test sets while assigned to Mountain Home AFB, Idaho and Kunsan AB, Korea. In 1980 he was selected for the Airman Education and Commissioning Program and after returning from Korea attended the University of Utah where he majored in Mechanical Engineering and graduated with honors in December 1982. After graduating OTS in April 1983 he was assigned to the Boeing AFPRO in Seattle where he served as Systems Engineer first for the USAF AWACS and later for the Peacekeeper programs. In 1987 he volunteered for a special duty assignment at Los Alamos National Lab on a Beryllium alloying and processing research project. In July 1989 he was assigned to Wright-Patterson AFB, Ohio as an integration engineer on the Tacit Rainbow program. He moved to the SRAM program in April 1991 where he was SRAM T Lead Engineer. He moved to the F-16 program in December 1991 where he is the Chief Systems Engineer for the Portuguese F-16 A/B and the Egyptian F-16 C/D programs.

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13. ABSTRACT (Maximum 200 words) The purpose of this study was to determine how much time Air Force acquisition engineers spend in performing management functions, how those engineers perceive their management training, and which types of training contribute the most to managerial competency.

The results from surveys of 280 acquisition engineers assigned to ASC/EN, Wright-Patterson AFB OH and their supervisors revealed that engineers do indeed spend substantial amounts of time performing management functions. Slightly more than half the engineers reported spending at least 50% of an average workday performing management functions.

Over 53% of engineers responding to the survey felt their management training had been either "excellent" or "good." Management skills were rated either "excellent" or "good" by 72% of the respondents. In the key area of communication skills, 87% agreed they had the necessary communication skills to be successful in their jobs.

The most effective contributors to managerial competency were experience, an aptitude for management, and having a mentor. Items rated least effective in improving management abilities included Professional Military Education and acquisition classes.

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